THE *Petroleum* Engineer — Management Edition

Exploration—Drilling—Producing • Refining—Petrochemicals—Gas Processing • Oil and Gas Pipelining

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The "Give-Away" That Returned a Fortune

Whether the amount of money bid for leases in the Outer Continental Shelf off the coast of Louisiana surprised anyone else it certainly did officials of the U. S. Department of the Interior. Interior expected to receive something like $50,000,000 for 199 tracts originally scheduled to be offered. Before they went on sale 19 tracts were withdrawn because of disputed ownership. The State of Louisiana claims that its boundary extends three leagues (10½ miles) into the Gulf of Mexico and, therefore, includes these tracts. This point is still to be settled. From the remaining 180 tracts offered, the federal government received bids totaling $129,500,000 for 97 of them.

This is not all, either, that will be realized from these 97 tracts. There is yet to come the royalties from any oil and gas produced. In all it has been estimated that the total will increase to approximately $500,000,000. And it hardly needs pointing out that the government owns many more tracts not yet sold. These latter, incidentally, show evidence of increasing in value due to the fact that the ones farthest from shore are the least attractive. The recent bidding, however, revealed that operators are becoming more venturesome and are willing to go into deeper water. The 6 highest bids were on tracts in water 40 to 60 ft deep.

The Louisiana bidding prompted the Secretary of the Interior to remark that here was evidence that the tidelands had not been a "give-away" matter. True, the question of state ownership of its tidelands did not relate to the Outer Continental Shelf but it has a direct and important bearing. The bearing has to do with federal and state land laws. State land laws stipulate that leases obtained thereon must be by competitive bidding. On the other hand, leases on public lands can be obtained simply by filing an application, or in legal terminology an "offer to lease." But thinking changed with respect to the Outer Continental Shelf as a result of successes in the tideland areas. The great possibilities indicated there resulted in federal regulations patterned after those of the states, that is, leasing by competitive bidding.

Obviously, Secretary McKay's statement is correct, and this seems to be a case where a so-called "give-away" has returned a fortune to the federal government.—*Frank H. Love.*

Having too many Sucker Rod pin breaks ?

...then you'll want to read THIS advertisement carefully!

*Studies on "UNNOTCHED Fatigue" vs. "NOTCHED Fatigue" offer sound engineering suggestions for reducing Sucker Rod pin failures.

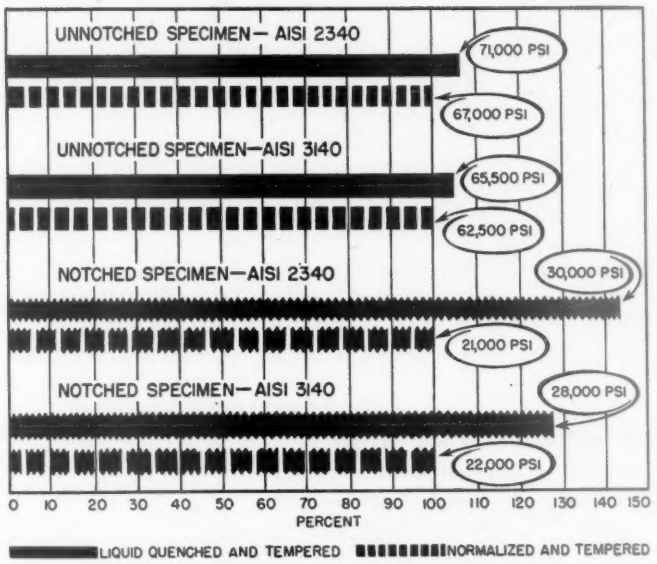
THE CHART at the right is based upon the findings of nationally-known authorities on FATIGUE in steel.* It illustrates the effect of a complete liquid quenching and tempering heat treatment upon the fatigue characteristics of UNNOTCHED and NOTCHED specimens in two popular alloy steels—AISI 2340 and 3140.

UNNOTCHED or "polished" specimens that are liquid quenched and tempered have greater fatigue resistance than rods that have only a normalized and tempered heat treatment.

And in NOTCHED specimens, which closely correspond to sucker rod pins, liquid quenching and tempering results in substantial increases of 43% and 27% respectively.

CONCLUSION—It is evident from these studies that the complete heat treatment of LIQUID quenching and tempering, used for "Oilwell" Grade "T" Sucker Rods, not only improves the body strength of rods but helps greatly to counteract thread-base fatigue; thus extending the service life of sucker rod pins.

Percentage Increase in Fatigue Strength by Liquid Quenching



Try "Oilwell" Grade "T" Sucker Rods

... in your heavy wells. Every rod is (1) liquid quenched, (2) drawn or tempered, (3) stretch straightened, (4) proof-tested, and (5) carefully inspected for thread accuracy. Grade "T" rods have an excellent record in heavy wells ... with extremely rare cases of pin failure.

*T. J. Dolan and C. S. Yen, American Society for Testing Materials Proceedings—Vol. 48, 1948, p. 664.

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UNITED STATES STEEL CORPORATION

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Export Office—
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NEW YORK 20, N. Y.

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Branches Serving All Oil Fields

USS TRADE MARK "OILWELL" TRADE MARK

UNITED STATES STEEL

XUM

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Asks Gas Import Authority

The FPC has been asked by Montana Power Company for authority to import natural gas from Canada. Gas would be produced or purchased and delivered to Montana by its Canadian subsidiaries. Montana was authorized by FPC in 1952 to import up to 40,000,000 cu ft of gas daily and a maximum of 10 billion cubic feet annually to serve the Anaconda Copper Mining Company. The authority expires April 7, 1956.

★ ★ ★

Marcy Sells Stock

Marcy Exploration and Mining Company, Inc., of Delores, Colorado, has sold 30 per cent of its common stock to Houston Oil Company of Texas. The Houston company has an option to purchase more stock, up to 50 per cent, during the next 3 years. Harold Decker, president of Houston Oil, is reported to have said that the company purchased the stock "in the feeling that uranium eventually will be a competitive fuel with petroleum."

★ ★ ★

Car Sales Rise

British government restrictions on automobile installment buying are off. Car sales for July, 1954, topped 1953 by 46 per cent. Delivery of cars now may take 18 months. Dealers charge a down payment of one-twentieth, the remainder in installments running 2 years.

★ ★ ★

Pipe Line Capital High

Capital investment in Canadian pipe lines, both in and outside Canada, will have passed $1 billion by the end of this year.

★ ★ ★

AMA Releases Car Facts

Automobile Manufacturers Association has reported in its 34th edition of "Automobile Facts and Figures," that about 74 per cent of the passenger cars and 48 per cent of the trucks in the world are in the United States. AMA also reported that 42.7 billion gallons of gasoline were consumed last year.

Gas Price Hike Suspended

Natural gas rate increases totaling about $805,300 a year, proposed by Phillips Petroleum Company, have been suspended by the Federal Power Commission. FPC permitted Phillips to file proposed rate increases amounting to about $144,700 a year, as a result of payments of Texas production tax, effective September 1.

★ ★ ★

Levels Crude Price

Standard Oil Company (Ohio) has reduced the price of crude oil it purchases in Illinois, Indiana, and western Kentucky by 12 cents a barrel. The cut, from $3.02 to $2.90, places the price in line with 42-gravity sweet oil in the Mid-Continent area.

★ ★ ★

Oil Process Perfected

Can-Amera Oil Sands Development, Ltd., and Mill Creek Oil Company, Ltd., Calgary, have perfected a commercially practical process for separating oil sands of northeastern Alberta, announced S. M. Paulson, president. A portable field unit will be operated as a pilot plant at Bitumount. Paulson said this method of separation obtained a crude oil considerably superior to any previously produced from these sands.

★ ★ ★

Exploration Pact Signed

The Pakistan government has signed an agreement with Standard-Vacuum Oil Company to explore a 20,000-sq mile area of the country for oil. The government and the company will share costs on a 25-75 per cent basis. Standard will purchase any of the government's 25 per cent of any oil produced at well-head value. Ganges River Delta area and Indus River Valley are to be explored.

★ ★ ★

Allowance to Be Studied

Hugh A. Steward, acting director of The Oil and Gas Division of the Department of Interior, has announced that the division is expected to undertake a study on the significance of oil and gas depletion allowance as related to exploration and development.

Sun Completes Tanker

Sun Oil Company has completed its $7.5 million supertanker, S. S. Western Sun, which was financed without government subsidy. The ship, third of a series being built for Sun, can carry 10,542,000 gal of petroleum. The new ship boosts Sun Oil's ocean-going fleet to 19 vessels.

★ ★ ★

Oil Demand Increases

Foreign countries will increase their demand for petroleum by about 7 per cent this year, B. Brewster Jennings, president, Socony-Vacuum Oil Company, predicted. An increase of about 3 per cent is expected in the United States. He forecast that natural gas usage in the United States will continue its large increases, which have amounted to 85 per cent over the past 6 years.

★ ★ ★

Oil Union Merge

Oil Workers International Union has merged with the United Gas, Coke and Chemical Workers to become Oil and Chemical Workers International Union. CIO president Walter Reuther said that organization of the "giants" of the chemical and oil companies would be a top CIO objective.

★ ★ ★

U. K. Equipment Sales Up

Sales to the oil industry made by British equipment firms during the first half of 1954 have increased by almost $8,400,000 over the corresponding period of last year. Council of British Manufacturers of Petroleum Equipment puts the total value at $109,200,000, not including oil tankers which represent more than half of all shipping tonnage ordered in U.K. yards.

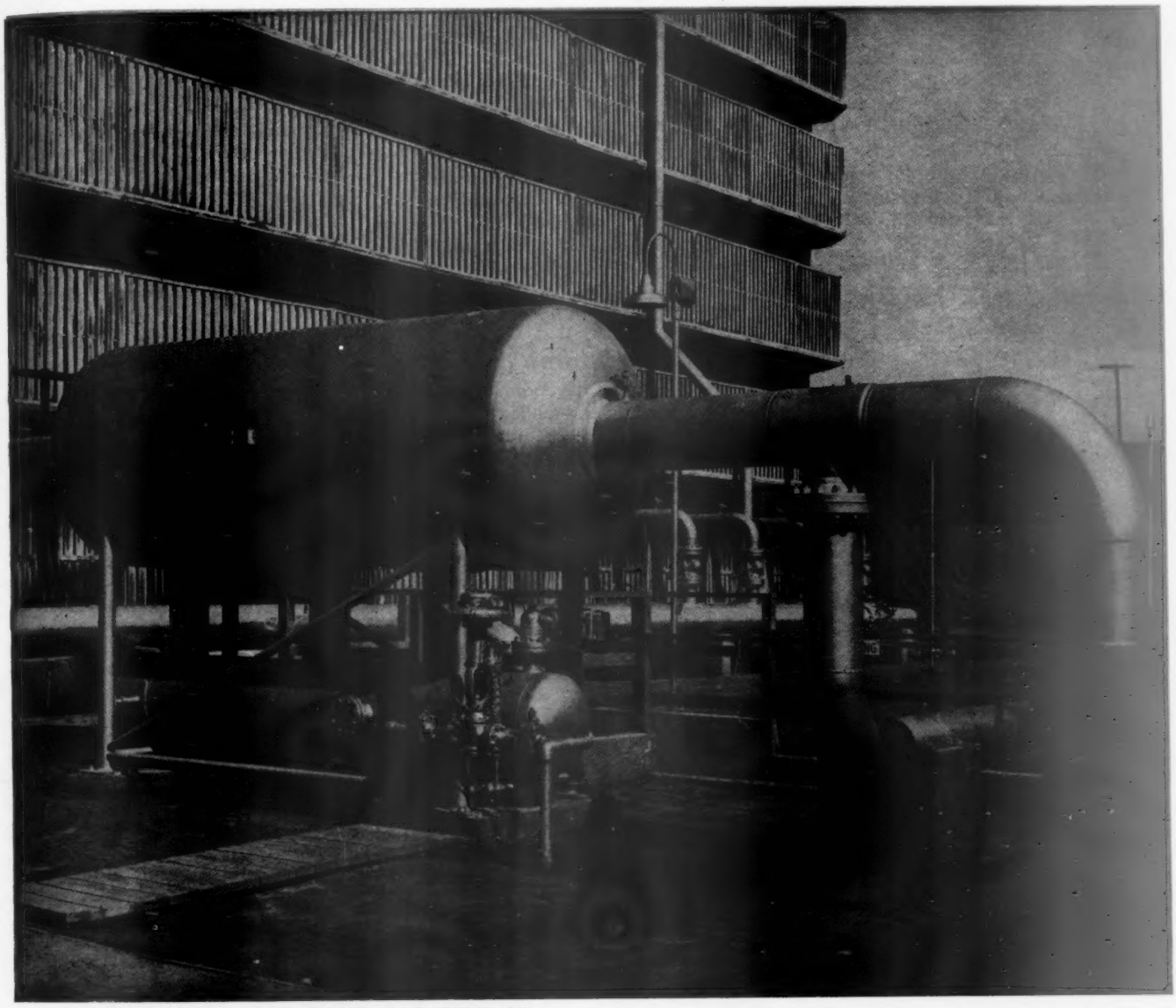
★ ★ ★

Oil Merger Approved

A merger of Colorado Oil and Gas Corporation and Derby Oil Corporation has been approved by the boards of directors. Colorado Oil and Gas, the surviving company, will form a wholly owned subsidiary to be called Derby Refining Company to operate the refinery pipe line of the merged company.

XUM

See PEERLESS FIRST!
For GAS SCRUBBERS...



The BEST SCRUBBERS for PIPELINES, GATHERING SYSTEMS, COMPRESSOR STATIONS, PLANT INLET SCRUBBERS

Pictured above is a Peerless 60" O.D. x 15 foot horizontal separator, handling 240,000,000 cu. ft. per day at 350#.

This separator is removing condensed liquid from the cooling tower to prevent moisture accumulation in distribution units.

Consult Peerless for an engineered solution to your most stringent entrainment problems.

PEERLESS MFG. CO.

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 ★ DALLAS, TEXAS ★ DIxon-8431

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Oil Storage Increases

Petroleum industry will have storage capacity of 1,020,000,000 bbl of crude oil, clean products, and residual fuel oil by December 1, the National Petroleum Council has reported. This is an increase of 160,000,000 bbl since March 31, 1948. The March 1954 ratio indicates that 100 bbl of storage is required for every 47 bbl of inventories contained therein, if the industry is to have flexibility for normal operations.

★ ★ ★

Oil Allowable Raised

A daily oil allowable for Texas of 2,864,749 bbl has been set for November, giving a 64,300 bbl increase over October's figure of 2,800,449 bbl. This is the largest quota since July. Buyers had requested an average of 2,784,231 bbl daily for November.

New wells put on the schedule will run the total gain to about 100,000 bbl daily during the month. A 15-day schedule was adopted by the Railroad Commission.

★ ★ ★

Atomic Energy Not Threat

Atomic energy will not adversely affect any important phase of the oil industry in the foreseeable future, said Dr. Robert E. Wilson, chairman, Standard of Indiana. The oil industry will benefit from it, if anything, he added. Wilson said that most specialists agree that few, if any, atomic power plants will be built for purely commercial purposes in this country in the next ten years, that these would be only at points remote from conventional fuel supplies.

★ ★ ★

Gas Heating Hits Peak

Shipments of gas-operated home heating furnaces hit a 4-year high in August. The August shipment of 69,800 units was the third largest month in the industry's history, topped only by September and October of 1950. Shipments were 29 per cent higher than for August, 1953.

American Gas Association has reported that in the past 5 years gas-heated homes have increased more than 1,000,000 per year. Installations during this period were more than the total number of homes heated by gas in the history of the gas utility industry. Association estimates that more than an additional 3,500,000 homes will be heated by gas in the next 3 years.

World Crude Production Up

Crude oil production on a worldwide basis increased 6 per cent over 1952 figures, totaling 4772 million barrels in 1953. The Middle East output, 902,000,000 bbl, topped the 1952 figure by 16 per cent. Production in Indonesia increased 20 per cent; Canada, 32 per cent; United States, 3 per cent. Production in Venezuela was down 3 per cent from 1952. U.S.S.R. is estimated to have produced 370,000,000 bbl of crude in 1953, compared to an estimated 329,000,000 in 1952.

★ ★ ★

Coal Men Blame Policy

The National Coal Association, contending that federal policy is responsible for much of the industry's distress, formally petitioned a government committee to recommend putting restraints upon the "unwarranted expansion of the natural gas industry at the expense of coal." The association deplored "benevolent federal policy aimed at promoting widespread use of natural gas." The association said that consumption of coal has declined sharply in the face of a rising demand for energy and called for steps to restore a "balance" between the two industries.

★ ★ ★

Gas Companies Exempted

Seven more intrastate gas companies have been exempted from FPC regulations because they are controlled by state commissions. The firms are Huntingdon Gas Company, Citizens Gas Company, Shippensburg Gas Company, and Bangor Gas Company, all of Oxford, Pennsylvania; Lawrenceburg Gas Company, Lawrenceburg, Indiana; South Jersey Gas Company, Newark, and Mayfield Gas Company, Mayfield, Kentucky. Companies which buy and sell all their natural gas within one state and which are under state commission regulations can be exempted from FPC control under a law passed by Congress during the last session.

★ ★ ★

Aussie Oil Consumption Up

Australia's national development minister has predicted a rise of 9 per cent in over-all consumption of oil products this year. He predicts Australia will consume 786,000,000 gal of gasoline compared with 721,000,000 gal last year.

AAODC Elects Officers

J. V. Dunbar, Denver, Colorado, has been elected president of the American Association of Oilwell Drilling Contractors. C. F. Whaley, Houston, Texas, was named vice president. Other officers, all of Dallas, Texas, are L. A. Beecherl, treasurer; W. L. McClusky, secretary; Brad Mills, executive vice president, and Marion S. Church, general counsel.

Regional vice presidents include: West Texas and New Mexico, H. W. Davidson, Midland; Gulf Coast, W. S. Fitzpatrick, Corpus Christi; West Central Texas, John J. Moran, Wichita Falls; Central Mid-Continent, Dee A. Sikes, Tulsa; California, Robert L. Rose, Los Angeles; Illinois, Michigan, Indiana, and Kentucky, Alva C. Davis, Fairfield, Illinois. Other vice presidents are: Cretaceous and Tertiary Basins, Herbert A. Woolf, Tyler, Texas; Cable Tools, Gail C. Cutler, Tulsa, and Well Servicing, J. K. Butler, Houston.

★ ★ ★

Shutting-in Deplored

"Underproducing—developing wells and then being forced to shut them in—in order to accommodate the oil coming into this country from foreign areas" was termed one of the most important problems of the oil industry by Reese H. Taylor, Union Oil Company of California president. He said that in the face of a record free world production of crude oil in the first six months of the year, the United States has produced less crude oil than it did last year.

★ ★ ★

Iran Has 7-Year Plan

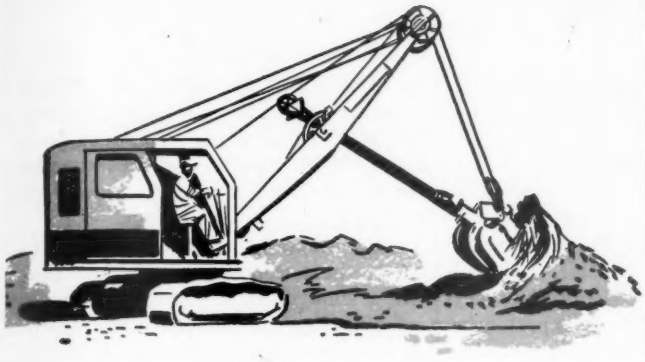
Iran plans to spend more than $700 million in oil revenues under a 7-year development plan. The program, aimed at solving Iran's unemployment problem and giving the nation's living standard a major boost, will lean heavily on foreign borrowing during the first two years.

★ ★ ★

U. S. Leases Tidelands

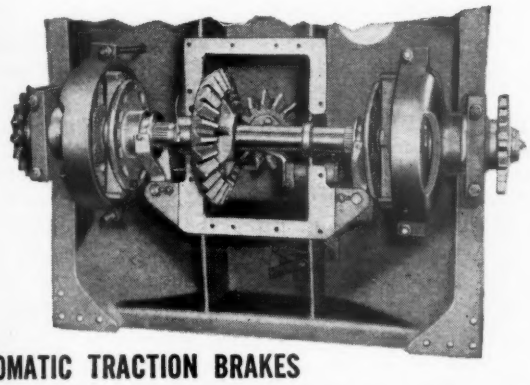
The Interior Department's action in putting up off-shore tracts for oil and gas leasing for the first time has assured approximately $130 million in revenue from the sale of leases. The government offered 180 tracts for oil and gas leases and 108 tracts for sulfur leasing. All receipts from the offshore leases will go into the federal treasury, as will rents and royalties.

COMPARE Koekring 205 *with any other half-yard:*



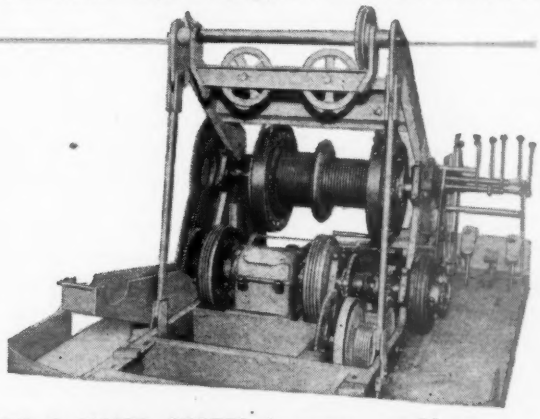
BIG 20-INCH MAIN DRUM CLUTCHES

Operating clutches in the Koehring heavy-duty 205 are among the largest size used in the ½-yard class. You get: 20x3" crowd clutch . . . 18x3" clutch on swing . . . 14x3" clutch on boom-hoist and retract. All clutches are of the internal expanding type . . . with reversible bands.



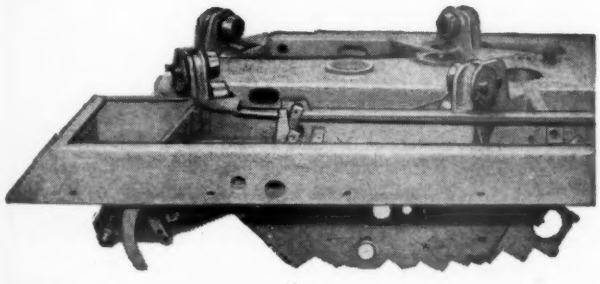
AUTOMATIC TRACTION BRAKES

Brakes are automatically engaged at all times, except when tractive power is applied. This simplifies operation . . . locks and holds the 205 when working or parked. Traction brakes are of the internal expanding type . . . reversible bands require no adjustment for the life of the lining.



ONLY 2 MAJOR SHAFTS in upper machinery

With just a main-drum shaft, and a swing-and-traction shaft there are fewer parts in the 205's upper machinery. Maintenance is simplified. Each assembly is an independent unit mounted on antifriction bearings. Splined shafts and carburized hardened gears assure maximum strength.



4 HOOK-ROLLERS . . . eccentric adjustment

Revolving turntable is held securely to carbody by 4 conical hook-rollers that resist tipping in any direction. Rollers are mounted on non-metallic bushings . . . and are readily accessible for easy eccentric adjustment. Turntable rollers coincide perfectly with machined roller path.

With HEAVY-DUTY 205 you also get:

- Antifriction power-flow for dig, hoist, swing and travel
- Standard or extra-long crawlers with 16, 20, 24" shoes
- Independent traction . . . optional
- Rubber-tired truck mounting, 32½ m.p.h. travel speeds
- ½-yard hoe attachment (digs 32" wide, 17¾' deep)
- ½ to ¾-yard capacity clamshell or dragline
- 10-ton capacity as crawler crane; 15-ton truck crane

All these Koehring 205 advantages add up to a big "plus" in WORK CAPACITY over any other machine in the ½-yard class. Before you invest in any excavator or crane, be sure to look into this new ½-yard, 10-to-15 ton 205. Call your Koehring distributor soon . . . or write for bulletin.

To: **KOEHRING COMPANY, Milwaukee 16, Wisconsin**
Send us bulletin on the new ½-yard, 10-to-15-ton 205.

NAME_____ TITLE_____

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K488 PE

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Subsidiaries: PARSONS • KWIK-MIX • JOHNSON

PETROLIC PERSONALITIES

DICK SNEDDON

A SUBSTITUTE FOR MARCIANO

We foregathered in one of the better western hostelries the other night with Dave Day, popular prexy of the Los Angeles Petroleum Club and vice president of Richfield Oil Corporation; Jim Kelley, the Hillman-Kelley partner, who is doing a bang-up job as activities chairman of the Club, and Ed Stout, a public relations higher-up from General Petroleum Corporation. During this interesting seance we heard some of the amazing exploits of that amazing character, Hack "Coach" Sickler, one of the A. O. Smith Corporation's better known sales representatives.

Recently, for example, Hack learned that Rocky Marciano, following his defeat of Ezzard Charles, was scheduled to put in an appearance at the Costa Grill in Los Angeles. About the time Rocky was due to appear, Hack bounced into the cafe with his nose all taped up, waving his clasped hands and acknowledging the plaudits of the patrons in typical prize fighter style. In a few minutes he dodged out of the place again, leaving everybody thrilled no end to have seen the great Marciano in person. When the real heavyweight champ arrived somewhat later, we are told that his welcome was neither so spontaneous nor so sustained as the one that was tendered to the great Sickler.

THE PARKERS ARE SPEEDY

Bryce Parker, assistant landman for Monterey Oil Company in San Antonio, is an accomplished but modest chap who has the kind of background of which interesting biographies are made. He was an outstanding football player at Jefferson High School in San Antonio, was a top ranking football player on one of the Rice Owl's better teams before the war, and was also for a time a member of Rice's varsity track squad. Proving that speed is a family trait, his younger brother, Charlie, held the intercollegiate record in the 100 yard dash until Mel Patton clipped a fraction off his time and ruined the whole thing. Following his graduation from St. Mary's University School of Law in San Antonio, Bryce was admitted to the Texas State bar in 1949 and prior to joining Monterey in 1953 had been about 7 years with Rock Hill Oil Company, first as a landman and later as assistant secretary. His hobbies nowadays are Herbert Bryce Parker III, aged 7, and Scott Leland Parker, aged 2. It is said, incidentally, that the youngsters operate in typical courtroom style. When Bryce II reaches the end of his questioning, he turns to his younger brother and says, "Okay, Scott, your witness!"

EVEN FROM FINDLAY THEY CAME

The Petroleum Production Pioneers' fall barbecue at Ventura was one of the best of all time with more than a thousand members and friends enjoying the delicious steaks provided by Fritz Huntsinger, the Ventura Tool Company president; Martin Mears, the Tidewater Associated drilling chief; George Ruggles, the CCMO hotshot; Alex McLean, the elevated flying horseman, and all the rest of their Barbecue Associates.

Colonel Hudson Drake, the Belridge purchasing potentate, and his admirable aides poured the warming waters with a fast and generous hand, and thereby promoted such a rash of reminiscence as hasn't been heard since Chaucer's boys assembled at the old Tabard Inn in Southwark and told their Canterbury Tales.

Among the out-of-town members attending this considerable whingding was Fred Smith, the Ohio Oil Company production executive from Findlay, Ohio, who has just completed his first 40 years with the company. He began his oil career as office boy in Marshall, Illinois, and meantime has scattered his efforts widely over the producing areas of the United States, while climbing the success ladder.

In his leisure moments Fred is an enthusiastic skeet shooter, and no wonder—there is nothing more appetizing than broiled skeet with a smidgen of onion sauce. He also is an expert hunter of elk, deer, moose, and other carnivorous mammalia; has an astonishing collection of modern firearms,, and knows more about the Ohio Oil Company than old man Ohio himself.

GREETINGS FROM GASPE

We have a couple of cards from Bob Burns, the Torrance tycoon who officiates as an important half of McDonald & Burns. They were datelined from Halifax, Nova Scotia. He and Mrs. Burns were on a sight-seeing trip by auto through Canada and up to the moment of writing had visited Toronto, Ottawa, Montreal, and Quebec, and had traveled along the banks of the beautiful St. Lawrence River to its mouth. They made the tour around the Gaspe Peninsula and then went on to St. John, New Brunswick. Thence they crossed back to our side of the border, spent some interesting time in Boston, New York, and Washington, D.C., up to which time they were in good shape and thoroughly enjoying their trip.

A later communique from Bob, however, brought the disconcerting news that partner, Archie MacDonald was in the Cedars of Lebanon Hospital, so we called and had a chin with Archie. We found him a bit weak but recovering nicely from a serious operation that became necessary very suddenly and very unexpectedly. Archie is one of the best and we are certainly wishing him a fast and full recovery.

"THE PIPE LINE BACK THERE SHOULD COST THE COMPANY LESS BECAUSE IT'S SMALLER!"

Meetings

Nov. 8-9—**Gas Measurement Institute,** University of Kansas Extension and Southwest Kansas Petroleum Industry, Legion Hall, Liberal, Kansas.

Nov. 8-11—**American Petroleum Institute,** annual, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 11-12—**American Association of Petroleum Geologists,** annual, Pacific section, Biltmore Hotel, Los Angeles, California.

Nov. 15-17—**Council on World Affairs,** Petroleum and other raw material needs.

Nov. 15-17—**American Petroleum Credit Association,** annual, Muehlebach Hotel, Kansas City, Missouri.

Nov. 15-17—**American Standards Association,** annual, Roosevelt Hotel, New York, New York.

Nov. 15-17—**National Conference on Standards,** annual, Roosevelt Hotel, New York, New York.

Nov. 17-18—**American Institute of Mechanical Engineers,** North Texas section, and **North Texas Oil and Gas Association,** production committee, symposium on secondary recovery, Wichita Falls, Texas.

Nov. 18—**National Industrial Conference Board,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 18-19—**National Association of Corrosion Engineers,** annual, Biltmore Hotel, Los Angeles, California.

Nov. 18-19—**Society of Exploration Geophysicists,** Midwestern division, annual, Adolphus Hotel, Dallas, Texas.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Nov. 29-30—**Packaging Institute,** New York, New York.

Nov. 30-Dec. 2—**Electronic Computer Clinic and International Automation Exposition,** 244th Regiment Armory, 14th St. between 6th and 7th Avenue, New York, New York. Address inquiries to Electronic Computer Clinic, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania.

Dec. 2-4—**American Chemical Society,** Southwest regional, Fort Worth, Texas.

Dec. 3-4—**Interstate Oil Compact Commission,** Winter meeting, Drake Hotel, Chicago, Illinois.

Dec. 2-7—**National Exposition of Power and Mechanical Engineering,** Commercial Museum, Philadelphia, Pennsylvania.

Dec. 3—**Instrument Society of America,** Philadelphia section, Commercial Museum, Philadelphia, Pennsylvania.

Dec. 3—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.

internal swivel action gives you two-way control over movement of piping

To get complete information, write for your copy of Bulletin No. 54.

You can readily control both the lateral and longitudinal swing movements of your piping up to 7° with our functional spring hanger.

For the hanger is designed with the Blaw-Knox patented *internal swivel action*, which permits movement while the hanger case itself remains vertical. Larger movements are readily accommodated by overhead roller assemblies. Each is a complete packaged unit ready to install.

In fact, our entire line of rigid hanger assemblies, overhead roller assemblies, vibration eliminators, as well as the functional hangers, are furnished as complete units . . .. thereby saving you engineering time and eliminating expensive cutting, threading and assembling in the field.

Our engineers, who have had years of experience, are available to both design and make recommendations for your hanger requirements.

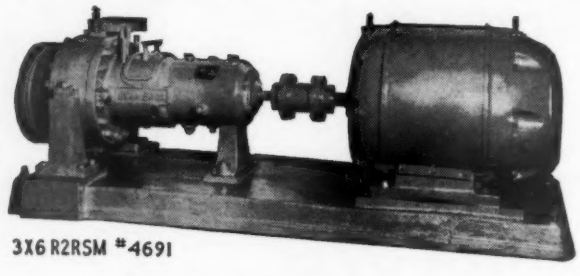
BLAW-KNOX COMPANY, Power Piping and Sprinkler Division, Pittsburgh 33, Pa.

BLAW-KNOX **PIPE HANGERS**

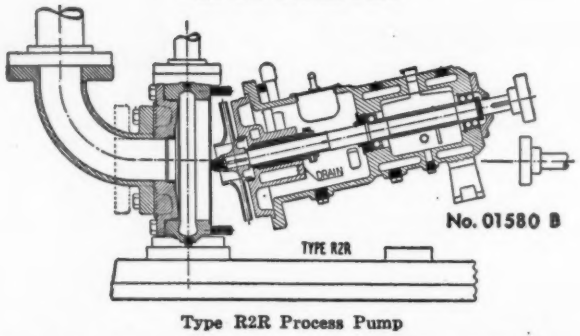
Complete line of functional spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated power piping systems for all pressures and temperatures.

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

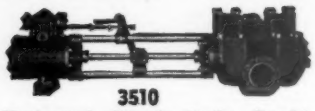
DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

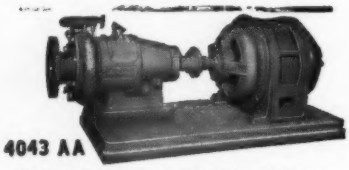
BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL AND RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

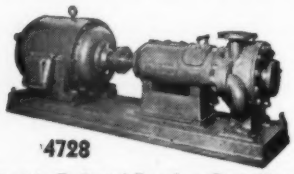


Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

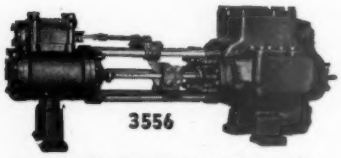


Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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Representatives in Principal Cities

Dec. 12-15—**American Institute of Chemical Engineers,** annual, Statler Hotel, New York, New York.

Dec. 27-30—**American Association for the Advancement of Science,** University of California, Berkeley, California.

1955

Jan. 10-14—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Michigan.

Jan. 17-18—**Kansas Oil Men's Association,** annual, Baker Hotel, Hutchinson, Kansas.

Jan. 17-19—**Pipe Line Contractors Association,** Statler Hotel, Los Angeles, California.

Jan. 20-21—**National Industrial Conference Board,** Hotel Astor, New York, New York.

Jan. 24-27—**American Society of Heating and Ventilating Engineers,** annual, Philadelphia, Pennsylvania.

Jan. 26-28—**Symposium on Instrumentation for Process Industries,** Texas A&M College, College Station, Texas.

Jan. 27-28—**American Chemical Society,** Southeastern Texas section, symposium on hydrocarbon chemistry, Houston, Texas.

Feb. 10-12—**Institute of Radio Engineers Conference and Electronics Show,** Baker Hotel, Dallas, Texas.

Feb. 13-17, 1955—**American Institute of Mining and Metallurgical Engineers,** annual, Conrad Hilton Hotel, Chicago, Ill.

Feb. 14-16—**American Association of Petroleum Geologists,** Rocky Mountain regional, annual, Billings, Montana.

Feb. 16-18—**National Association of Corrosion Engineers,** annual short course for pipeliners, Mayo Hotel, Tulsa, Oklahoma.

Feb. 25—**Natural Gasoline Association of America,** Permian Basin regional, Scharbauer Hotel, Midland, Texas.

March 9-11—**American Petroleum Institute,** Southwestern District, Division of Production, Jung Hotel, New Orleans, Louisiana.

March 20-23—**American Institute of Chemical Engineers,** Kentucky Hotel, Louisville, Kentucky.

Mar. 24—**National Industrial Conference Board,** Shamrock Hotel, Houston, Texas.

Mar. 28-Apr. 1—**Ninth Western Metal Exposition,** American Society for Metals and 19 other technical societies, Ambassador Hotel, Los Angeles, California.

Mar. 28-31—**New York Oil Finders Convention,** the American Association of Petroleum Geologists, the Society of Economic Geophysicists, and the Society of Economic Paleontologists and Mineralogists, annual, Statler Hotel, New York City, New York.

April 13-15—**Natural Gasoline Association of America,** annual, Baker and Adolphus Hotels, Dallas, Texas.

April 19-21—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

May 1-4—**American Institute of Chemical Engineers,** Shamrock Hotel, Houston, Texas.

May 1-4—**Liquefied Petroleum Gas Association,** annual, Conrad Hilton Hotel, Chicago, Illinois.

May 9-12—**American Petroleum Institute,** midyear meeting, division of refining, Jefferson Hotel, St. Louis, Mo.

May 14-22, 1955—**Deutsche Gesellschaft fur Chemisches Apparatewesen,** chemical plant and apparatus exhibition and congress, Frankfurt am Main, Germany.

May 16-18—**American Petroleum Institute,** division of transportation, midyear committee conference, Edgewater Beach Hotel, Chicago, Illinois.

May 19-20—**National Industrial Conference,** Waldorf-Astoria Hotel, New York, New York.

June 6-15, 1955—**Fourth World Petroleum Congress,** Rome, Italy.

June 12-17—**SAE Golden Anniversary Summer meeting,** Chalfonte Haddon Hall, Atlantic City, New Jersey.

June 16-18—**Interstate Oil Compact Commission,** Cosmopolitan Hotel, Denver, Colorado.

Sept. 12-16—**Instrument Society of America,** National Instrument conference and exhibit, Los Angeles, California.

Sept. 25-28—**American Institute of Chemical Engineers,** Lake Placid Club, Lake Placid, New York.

Nov. 14-17—**American Petroleum Institute,** annual, San Francisco, California.

Nov. 27-30—**American Institute of Chemical Engineers,** annual, Statler Hotel, Detroit, Michigan.

Oct. 2-5—**American Institute of Mining and Metallurgical Engineers,** Petroleum Branch fall meeting, Roosevelt Hotel, New Orleans, Louisiana.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual meeting Statler Hotel, New York, New York.

Engineers Survey Training

A national survey of training programs for young engineers in industry has been launched by the Professional Engineers Conference Board for Industry in cooperation with the National Society of Professional Engineers.

John D. Coleman, Dayton, Ohio, an engineering executive for General Motors Corporation, will head the project. He will be assisted by 26 engineers from all parts of the country in all phases of the profession.

Purpose of the project is two-fold: To learn what is being done now in the field of engineer training, and to use this information to develop concrete suggestions that will be of value to management and professional engineers in all fields.

"The highly specialized projects that industry must support make the subject of engineer training a vital one for both engineers and management," said Coleman. He pointed out that a similar survey had disclosed that one firm spends approximately $5,000,000 per year to operate the equivalent of a graduate school for its young engineers.

The project will include sending detailed questionnaires on post-college engineering training to major industrial firms as well as selected large and small manufacturers. First-hand information on training programs was obtained by researchers who visited representative firms in various parts of the country, Coleman said.

This is the fourth in a series of reports conducted by the Conference Board.

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Tests show that daily use of COREXIT — the corrosion inhibitor for sour crude, gas condensate and other oil wells — can save you up to $800.00 per well per year. COREXIT'S patented compound protects against the severe corrosive conditions in wells by building up a protective coating on tubing and sucker rods.

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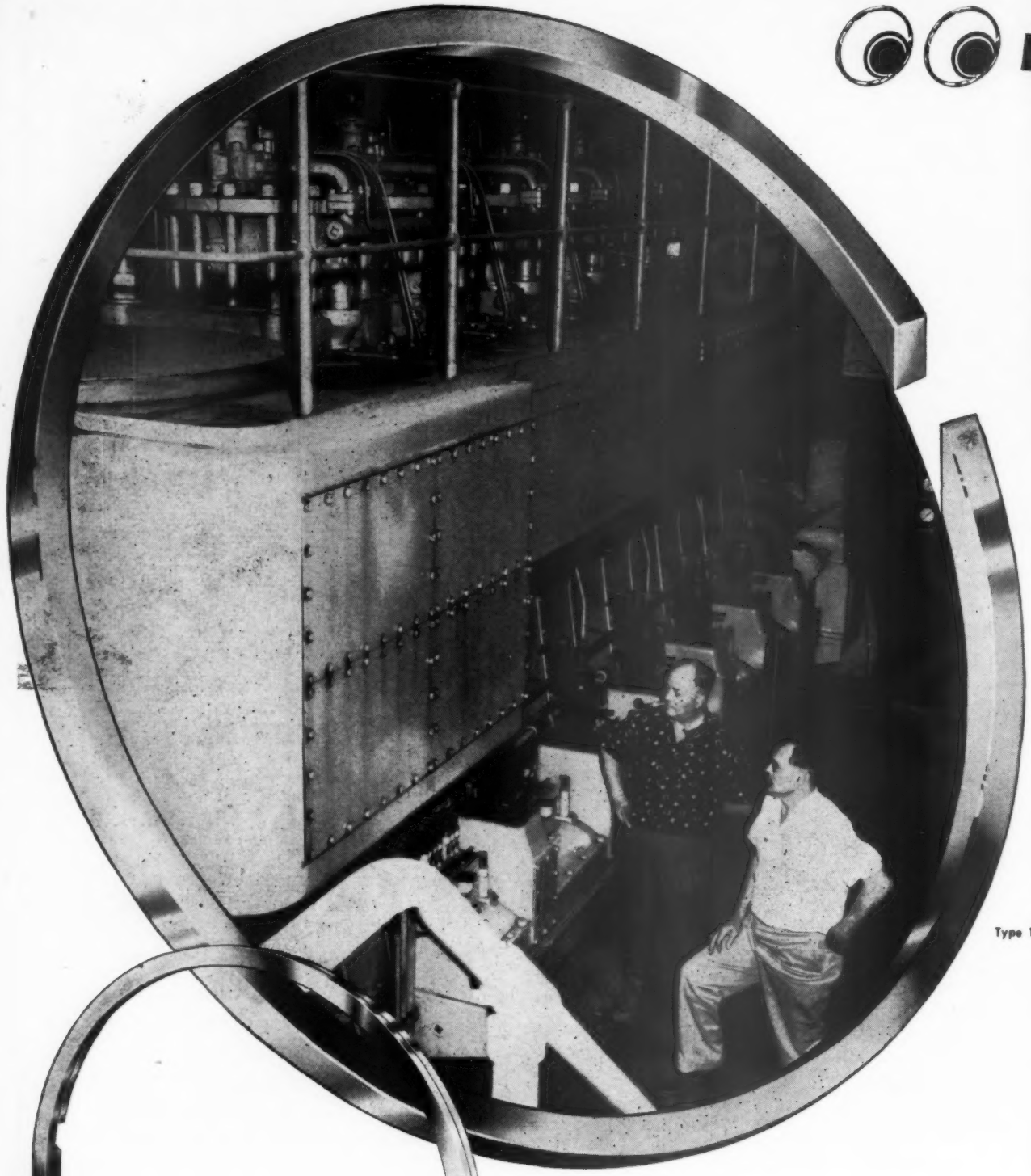

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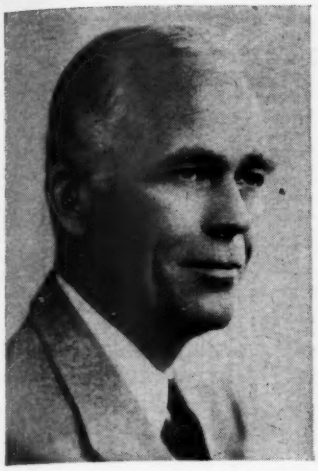
RE-TURNING MAKES BETTER RINGS!

Because they are re-turned as a final manufacturing process, Cook Piston Rings are light-tight, and conform perfectly to the cylinder wall. This eliminates the possibility of scuffing during initial operation. The perfect conformity of re-turned Cook Rings prevents hot gasses from blowing by and impairing lubrication when it is needed most. The result — *longer life and more efficient performance!*



JOHN J. PEW
Sun Oil Company
Production Division

JOHN W. NEWTON
Magnolia Petroleum Company
Refining Division

R. M. BARTLETT
Gulf Oil Corporation
Marketing Division

CHARLES S. JONES
Richfield Oil Corporation
Transportation Division

100,000 Committeemen Can't Be Wrong!

AMERICAN PETROLEUM INSTITUTE HAS 8000 COMMITTEES, WHICH HOLD FORUMS TO DISCUSS, ANALYZE, AND OFFER SOLUTIONS TO PROBLEMS OF THE PETROLEUM INDUSTRY

ERNESTINE ADAMS*

THE gigantic voluntary petroleum industry organization—the American Petroleum Institute—is made up chiefly of thousands of committees comprised of thousands of unpaid committeemen. There are so many, in fact, that no one can give an exact number at any specific time.

Back in 1949 an official count was made and the effort seems to have exhausted the counters; no overall record has been collected since. At that time there were 569 committees in the API, composed of 6647 persons. This count excluded Oil Industry Information Committee and the American Petroleum Industries Committee.

Right now the nearest figure on committees working on API business is given a wide range—500 to 600 with 6000 to 7000 persons involved. The OIIC is not included; it alone has 5000 committees and 20,000 committeemen. Nor is APIC included; it works with thousands of organized groups that are completely autonomous.

In addition to the above there are about two dozen "chapters" in the API Division of Production, which have committees of their own.

So what is the best estimate? More than 8000 committees and 100,000 committeemen! This gives some idea of the scope of API interests and of the effort to produce action to implement those interests.

Number of API committees and subcommittee fluctuates from month to month, which is the reason for the difficulty in keeping count. New committees are created as new projects are laid out; some terminate as their assignments have been completed; others go on indefinitely. Fundamental research, for instance, has one group that has been working on a continuing project for more than 25 years.

There is a wide range in the number of meetings held by the committees, depending upon their particular assignment and upon how active and enthusiastic the chairman and the members are about the project they are working on. Some may meet only once a year; others may schedule regular monthly or bi-monthly, meetings. At the mid-year and divisional meetings there are hundreds of committee meetings. At the annual meeting in Chicago there were 125 committee meetings scheduled and, in addition, a large number of informal sessions and unscheduled meetings were held.

Sizes of the committees show another wide variety. There are from 2 to 60 or more persons on each committee.

Organization of the API is shown in the full page chart on the following page. It gives in broad outline the Institute's operations: The four divisions and the five service departments, and the standing, special, and advisory committees of the Institute, which work with the government and other industries, and tackle overall problems of the petroleum industry.

Division of Production

First of the four divisions of API is Division of Production, which is

EXCLUSIVE

*Managing Editor.

ORGANIZATION OF AMERICAN PETROLEUM INSTITUTE

Large oil and gas association is based on committee system of operation.

BOARD OF DIRECTORS AND EXECUTIVE COMMITTEE
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VICE PRESIDENT FOR PRODUCTION
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MANAGEMENT OF STAFF
COMMITTEES OF THE BOARD AND THEIR SUBCOMMITTEES
AMERICAN PETROLEUM INDUSTRIES COMMITTEE WITH 5 STANDING SUBCOMMITTEES, 5 ADVISORY COMMITTEES, AND 42 STATE AND 3823 LOCAL AFFILIATED PETROLEUM INDUSTRIES COMMITTEES
PUBLIC RELATIONS AND ITS OIL INDUSTRY INFORMATION COMMITTEE WITH TEN SUBCOMMITTEES AND ELEVEN DISTRICT OFFICES
BOARD OF COUNCILORS
MEMBERSHIP COMMITTEE
NOMINATION COMMITTEE
AGRICULTURAL ADVISORY WITH COMMITTEE ON AGRICULTURE
SAFETY WITH CENTRAL COMMITTEE ON ACCIDENT PREVENTION AND FIRE PROTECTION AND A MEDICAL ADVISORY COMMITTEE AND AN L-P GAS COMMITTEE
RESEARCH WITH 2 ADVISORY COMMITTEES ON COMPOSITION AND PROPERTIES AND OCCURRENCE AND RECOVERY OF PETROLEUM AND FIRE PROJECT ADVISORY COMMITTEES
AWARDS, AND NATIONAL OR POLICY, AND PROGRAM AND BUDGET REVIEW
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PETROLEUM RESERVES AND STATISTICAL ADVISORY
STANDING AND SPECIAL COMMITTEES OF THE INSTITUTE
SERVICE DEPARTMENTS OF THE INSTITUTE
TECHNICAL SERVICES
STAFF WORK FOR AGRICULTURAL COMMITTEES AND PROGRAMS
STAFF SERVICES FOR ACCIDENT PREVENTION AND FIRE PROTECTION COMMITTEES AND RELATED ACTIVITIES
STAFF SERVICES FOR RESEARCH AND ENGINEERING COMMITTEES AND RELATED ACTIVITIES
OFFICE OF PRESIDENT
STAFF SERVICES FOR NON-DIVISIONAL AND INTERDIVISIONAL COMMITTEES AND RELATED ACTIVITIES (NOT OTHERWISE ASSIGNED)
ADMINISTRATIVE SERVICES
OFFICE OF SECRETARY AND ASSISTANT TREASURER
API HEADQUARTERS
INFORMATION
WASHINGTON OFFICE
STATISTICS
OPERATING DIVISIONS OF THE INSTITUTE
DIVISION OF PRODUCTION
GENERAL COMMITTEE
CENTRAL COMMITTEE ON STANDARDIZATION OF OIL FIELD EQUIPMENT WITH COMMITTEES ON:
DRILLING
BOILERS
CABLE TOOLS
DERRICKS
PIPE
VALVES AND FITTINGS
ROTARY DRILLING EQUIPMENT
WIRE ROPE
PUMPING EQUIPMENT
TANKS
GAGES & GAGING PRACTICE
OIL WELL CEMENTS
CENTRAL COMMITTEE ON VOCATIONAL TRAINING WITH EXECUTIVE COMMITTEE TECHNICAL ADVISORY COMMITTEE FORMULATING AND REVIEWING COMMITTEES LOCAL SCHOOLS
PROGRAM COMMITTEE
NOMINATING COMMITTEE
CENTRAL COMMITTEE ON DRILLING AND PRODUCTION PRACTICE WITH COMMITTEES ON:
DRILLING
PRODUCTION
PROGRAM
PUBLICATIONS AND DISTRICT SECTION AND STUDY COMMITTEES
CENTRAL COMMITTEE ON DISTRICT ACTIVITIES WITH DISTRICT ADVISORY COMMITTEES IN:
EASTERN DISTRICT
MID-CONTINENT DISTRICT
PACIFIC COAST DISTRICT
ROCKY MOUNTAIN DISTRICT
SOUTHWESTERN DISTRICT
CENTRAL COMMITTEE ON MEASURING, SAMPLING AND TESTING NATURAL GAS AND NATURAL GASOLINE WITH ITS SUBCOMMITTEE ON GAGING AND TESTING SPHERICAL AND SPHEROIDAL TANKS
DISTRICT AND CHAPTER ORGANIZATIONS AND MEETINGS
DIVISION OF REFINING
GENERAL COMMITTEE
AUTOMOTIVE RESEARCH COMMITTEE WITH 4 REGIONAL SUBCOMMITTEES: CHICAGO PACIFIC COAST PHILADELPHIA AND NEW YORK TULSA, AND WITH SUBCOMMITTEE ON SURVEYS
COMMITTEE ON DISPOSAL OF REFINERY WASTES WITH 4 SUBCOMMITTEES ON: OIL WATER SEPARATION SAMPLING AND TESTING CHEMICAL TREATMENT WASTE GASES AND DUSTS
COMMITTEE ON PETROLEUM PRODUCTS WITH 6 SUBCOMMITTEES ON:
ALKYLATE
OCTANE RECESSION
VAPOR TEMPERATURE DATA
VISCOSITY STANDARDS
COOPERATIVE LIBRARY SERVICE
TECHNICAL OIL MISSION
COMMITTEE ON ANALYTICAL RESEARCH WITH 5 SUBCOMMITTEES ON OXYGENATED COMPOUNDS EMISSION SPECTROSCOPY WASTE DISPOSAL ANALYTICAL METHODS
SULFUR & SULFUR TYPES
TRACE ELEMENTS
XRAY DIFFRACTION
COMMITTEE ON REFINERY CORROSION WITH 15 SUBCOMMITTEES ON:
CORROSION
ELECTRICAL EQUIPMENT
INSTRUMENTS
MECHANICAL EQUIPMENT
PRESSURE RELIEVING SYSTEMS
SAMPLING AND TESTING
VALVES (MFG)
REFINERY INSPECTION SUPERVISORS
TANK ACCESSORIES
TANK CLEANOUTS (MFG)
UNFIRED PRESSURE VESSELS
VALVES
VALVES (MFG)
CENTRIFUGAL PUMPS (MFG)
FIELD ASSEMBLED VESSELS
FIELD ASSEMBLED VESSELS (MFG)
COMMITTEE ON TRAINING WITH GULF COAST DISTRICT COMMITTEE AND 2 SUBCOMMITTEES ON:
TECHNICAL FIELD
TRAINING LITERATURE
NOMINATING COMMITTEE
PROGRAM COMMITTEE
ADVISORY COMMITTEE
DIVISION OF MARKETING
GENERAL COMMITTEE
AVIATION TECHNICAL SERVICE COMMITTEE
COMMITTEE ON DEVELOPMENT OF A SERVICE PROGRAM FOR MARKETERS WITH FIVE SUBCOMMITTEES ON:
FUNCTIONAL
FUEL OIL
PRODUCTS CONSERVATION
SERVICE STATION
VOCATIONAL TRAINING
LUBRICATION COMMITTEE WITH FOUR SUBCOMMITTEES ON:
EQUIPMENT
EDUCATION
NOMINATING
PROGRAM
PROGRAM COMMITTEE
DIVISION OF TRANSPORTATION
GENERAL COMMITTEE
OPERATING COMMITTEE
CENTRAL COMMITTEE ON AUTOMOTIVE TRANSPORTATION WITH 5 SUBCOMMITTEES ON:
BULK HAULING
ENGINEERING
OPERATIONS
REGULATIONS
TANK TRUCK SHIPPING PRACTICES WITH COMMITTEE OF REVIEW FOR UNIFORM SHIPPING PAPERS
CENTRAL COMMITTEE ON PIPE LINE TRANSPORTATION INCLUDING COMMITTEES ON:
ACCOUNTING AND VALUATION OF PIPE LINES
PIPE LINE TECHNOLOGY WITH SUBCOMMITTEES ON:
EXTERNAL CORROSION
PRODUCTS P-L TECHNOLOGY
INTERNAL CORROSION
LESS & LOSS PRACTICES
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P-L HYDRAULICS
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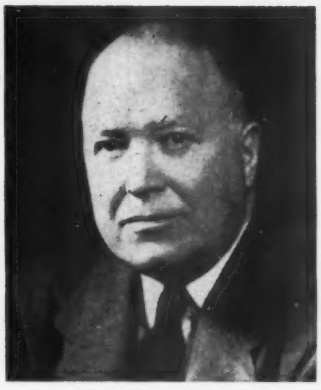
VOCATIONAL TRAINING
COMMITTEE ON LAW AND REGULATION
NOMINATING COMMITTEE
PROGRAM COMMITTEE
CENTRAL COMMITTEE ON RAILROAD TRANSPORTATION INCLUDING COMMITTEES ON:
CAR SERVICE
DIVERSION & RECONSIGNMENT
FREIGHT CLASSIFICATION
LEGAL SUBJECTS
RAILROAD EQUIPMENT
TANK CAR QUANTITIES
TRANSPORTATION REGULATIONS
CENTRAL COMMITTEE ON TRANSPORTATION BY WATER INCLUDING COMMITTEES ON:
PACKAGE CARGO
PROPOSED LEGISLATION
TANK VESSELS WITH SUBCOMMITTEES ON
GAS HAZARDS
OIL POLLUTION
TANKER CORROSION
CENTRAL COMMITTEE ON RADIO FACILITIES INCLUDING COMMITTEES ON:
LAW AND REGULATION
RADIO COORDINATION
RADIO ENGINEERING
GEOPHYSICAL USE
FIRE LINE USE
MARITIME USE
USE IN OIL PRODUCTION

P. C. SPENCER
Sinclair Oil Corporation
Chairman of the Board



FRANK M. PORTER
Fain-Porter Drilling Company
President

B. BREWSTER JENNINGS
Socony-Vacuum
Treasurer

LACEY WALKER
Secretary and
Assistant Treasurer

concerned with technology, equipment, and methods used in drilling and production. Headquarters for this division are in Dallas, Texas, under the direction of William H. Strang.

The vice president of the API in charge of production heads the division. The office is held by John J. Pew, Sun Oil Company. He is chairman of the General Committee of the division, which acts on and approves all special reports or publications; it also recommends the production policies and problems to be placed before the Board of Directors.

There are 50 members of this General Committee, 45 of whom are elected annually by division members and 5 are appointed by API President Frank Porter from the members of the Board of Directors.

The next in the Division of Production set-up is the Central Committee on Standardization of Oil Field Equipment, headed by John R. Suman, Standard Oil Company (N.J.) with H. W. Ladd, Stanolind Oil and Gas Company, as vice chairman.

This committee works on simplification of sizes, grades, and designs; on standardization of dimensions that affect interchangeability; stabilization and improvement of quality, and development of economical practices for care and use of equipment.

Results of this committee's work reaches into every phase of drilling and production. There are 11 major committees studying specific equipment and various subcommittees under these. When manufacturers comply with specifications agreed upon by these committees they are eligible for permission to use the API official monogram, which is registered with the U.S. Patent Office.

The Central Committee on Drilling and Production Practice, under the chairmanship of George E. Cannon, Humble Oil and Refining Company, has the objective of promoting better drilling and production practice.

This committee provides a forum for discussion of drilling and production practices and then it collects, analyzes, and disseminates information on methods. It brings to the attention of the General Committee any new problems in development and production and accepts from the general committee any assignments directed toward solving these problems.

Local forums are supervised and coordinated by the Central Committee on District Activities. B. J. Dowd of Union Producing Company is chairman and Harold Berg of Tidewater Associated is vice chairman of this committee. It is composed of five geographical districts, each of which has its own chairman, vice chairman, secretary-treasurer, and an advisory committee elected by its membership.

Local chapters may be organized in any of the five districts and presently there are 27 active chapters in the United States. For annual meetings of the 5 districts, combined attendance runs about 4500 members.

Central Committee on Training has the purpose of developing better workers and supervisors in the producing branch of the industry through training programs. L. E. Fitzjarrald, Phillips Petroleum Company, is chairman of the committee.

The work is divided into vocational training, which promotes specific courses of instruction, and supervisory development, which studies techniques of effective supervision. T. A. Atkinson, Douglas Oil Company, is chairman of Vocational Training and F. H. Willibrand, Sohio Oil Company, heads Supervisory Development.

Among other important committees of the Division of Production are: Steering Committee on Drilling Practice, Harold Denton of Sun Oil Company, chairman; Editorial Board, "History of Petroleum Engineering," D. V. Carter, Magnolia Petroleum Company, chairman; Steering Committee on Production Practice, S. C. Oliphant, Tennessee Producing Company, chairman; Publications Committee, Glenn M. Stearns, British-American, chairman; Correlating Committee on Cementing Practice, T. J. Fuson, Humble, chairman.

Division of Refining

John W. Newton, Magnolia Petroleum Company, is both API vice president for refining division and chairman of the General Committee. Work of the division includes: Advisory, analytical research, automotive research, disposal of refinery wastes, petroleum products, program, refinery equipment, and training.

The Advisory Committee, headed by E. B. McConnell, Standard of Ohio, is composed of all chairmen of the division's committees and the committees' sponsors. The group acts as a steering committee for refining problems referred to the division.

The Committee on Analytical Research serves as a forum for the development of the science of analytical chemistry for the petroleum industry. C. E. Headington, Atlantic Refining Company, is chairman.

C. E. Davis, Shell Oil, is the new chairman of the Automotive Research Committee. This committee deals with matters involving fuels and lubricants for automotive equipment. Its major purpose is to promote the most efficient use of automotive fuels.

Committee on Disposal of Refinery Wastes develops, collects, and publishes information for the assistance of refiners who seek to prevent escape of harmful or noxious materials from refineries. J. H. Easthagen, California Research Corporation, is chairman.

Testing methods come under the province of the Committee on Petroleum Products, which has R. C. Alden, Phillips Petroleum, as chairman.

The Program Committee is headed by C. M. Ridgeway, Pure Oil.

Standards and recommended practices that concern the design, construction, inspection, and repair of refinery equipment are studied by the Committee on Refinery Equipment. Russell

Venn, Humble, is chairman. Smoke and Fumes Committee is headed by W. L. Stewart, Jr., Union Oil of California and Committee on Training by D. S. Turner, Standard of Ohio.

Division of Marketing

The Division of Marketing, headed by API vice president of marketing, R. M. Bartlett, Gulf Oil Corporation, serves as a national forum for distributors and consumers of petroleum. Bartlett acts as chairman of the General Committee; John Harper, Harper Oil Company, is vice chairman, and Everett F. Wells, Ashland Oil and Refining Company, is secretary. There are 73 additional members of this committee.

Headquarters of the marketing division are in New York, with Adam Rumoshosky as director. Work of the division is carried out through these principal committees:

R. Cubicciotti, L. Sonneborn Sons, Inc., heads the Lubrication Committee, which cooperates with other groups in disseminating information, seeks to improve lubricating practices, and works on standardization of containers.

The Aviation Technical Services Committee cooperates with government and other agencies on technical and engineering matters relating to delivery, storage, and distribution of fuels and lubricants at airports and to the fueling of airplanes. W. D. Parker, Phillips Petroleum Company, heads this committee.

J. L. Minner, Shell Oil Company, heads the Fuel Oil Committee. John Harper, Harper Oil Company, is chairman of the Jobber Advisory Committee. Marketing Personnel Training Committee is under the direction of E. J. McClanahan, Standard Oil Company of California.

Chairman of Marketing Research Committee is Nelson H. Seubert, Standard Oil Company (N.J.). Herbert Willetts, Socony-Vacuum Oil Company, heads the Meeting Assistance Committee and B. L. Majewski, Great American Oil Company, is chairman of the Membership Committee.

Division of Transportation

One of the more complicated organizations is the Division of Transportation, which must deal with many forms of transportation, from oil and gas wells to service station pumps.

The General Committee on Transportation is headed by Charles S. Jones, Richfield Oil Corporation, the API vice president for transportation. George H. Hill, Jr., Cities Service Company, is vice chairman and Charles E. Spahr, Standard of Ohio, is secretary.

Transportation division headquarters are in Washington, D.C., and director is James K. Moss.

W. R. Huber, Gulf, is new head of OIIC, which alone has 20,000 unpaid committeemen working to improve public relations. Director of the OIIC is Admiral Miller, who, with a permanent staff, has headquarters in New York.

There are five large central committees dealing with transportation work. The oldest of these and oldest API committee is the Central Committee on Railroad Transportation. It was organized in 1918 by the National Petroleum War Service Committee. Purpose of the division is to work on problems of interest to the public, the railroads, and the petroleum industry. Fayette B. Dow, National Petroleum Association, is chairman.

Central Committee on Highway Transportation is headed by M. E. Nuttila, Cities Service Oil Company. Much of this committee's work is devoted to ICC regulations governing transporting of flammable liquids.

R. B. McLaughlin, The Texas Pipe Line Company, heads the Central Committee on Pipe Line Transportation. Under this central committee are the largest number of committees working on specific problems concerning pipe line transportation, such as: Pipe line technology, external corrosion, internal corrosion, lease tank practices, pipe line practices, pipe line hydraulics, construction practices, crossings, field welding, personnel training, accounting regulations, valuation of pipe lines, etc.

Central Committee on Transportation by Water is under the chairmanship of M. G. Gamble, Esso Shipping Company. This committee cooperates actively with the U. S. Coast Guard in the preparation and amendment of "General Rules and Regulations for Tank Vessels."

The expanding use of radio in the petroleum industry is studied by the Central Committee on Radio Facilities, headed by W. M. Rust, Jr., Humble. Among its objectives is to determine the industry's radio requirements for presentation to the Federal Communications Commission.

Are 8000 Committees Necessary?

If there is a question about the need for so many committees in the API, it would soon be answered by talking with some of the voluntary committeemen familiar with the operations of the Institute. Even duplication of committees, such as similar ones in various districts under the Production Division, are useful.

The divisions themselves constantly review and revise procedures to attain the most convenient and responsible method of processing ideas and decisions for use by the industry.

It is important to note that committeemen need not be members of API. This would limit committeemen to the 7000 individual memberships. Their companies may or may not have a company membership. They may even belong to another industry. Committee members are chosen chiefly for their experience in the field to be examined.

The fact that a large part of the petroleum industry management makes up the committees gives the organization a solid base down to the local level. Any individual capable of contributing to the industry has the opportunity to do so and he reaps the benefits of working on a problem that interests him with others who hold that same interest.

Some point out the difficulty of keeping any account of 8000 committees. Of course, no one person does, but there is remarkable coordination and cooperation within the divisions. Usually committees are appointed and assigned projects by another committee to which it reports progress. When its assignment is completed, the committee is discharged. The system is a triumph of decentralization.

One suggestion of some merit is that general committees be named from various divisions so that information and results of committee work can be shared at a local level. In the OIIC department, which has about 20,000 committeemen, committees are national, state, district, and city. Under a system such as this, representatives of various divisions could share reports of the problems and progress in each division.

This is not a studied analysis. It is a brief glimpse of the tremendous API framework of voluntary workers that links all the divisions of the industry. It will open the eyes of many to the vastness of the organization. It may help others to envision new roads to achievement by contributing to the industry from their own knowledge and experience. * * *

XUM

Here Are the Events

- Interstate gas pipe lines were subjected to regulation by FPC under Natural Gas Act of 1938 to assure reasonable rates for gas sold by pipe lines to distributors. It provided that the jurisdiction of FPC should not apply to production and gathering.
- In 10 separate cases involving independent producers between 1938 and 1951, the FPC ruled it did not have jurisdiction over prices at which independent producers sold gas.
- Congress passed legislation in 1950, which would have removed any doubt that producers of gas were exempt from federal regulation; bill was vetoed by President Truman.
- Supreme Court ruled June 7, 1954, that FPC had control over prices of natural gas sold in interstate commerce for resale.
- FPC order 174-A directed that no change in any rate, charge, or service in effect on or after June 7, 1954, should be made whether provided by contracts or not and that no sale should be discontinued without its approval.
- U. S. Supreme Court on October 14 refused to review its decision in the Phillips case.

Here Are First Results

- Three major gas transmission projects have been abandoned or postponed.
- Thousands of consumers are waiting for natural gas which is not available; about 100,000 in Chicago alone are on waiting list of applicants.
- Producing companies in Oklahoma with reserves sufficient to supply 150,000,000 cu ft of gas daily for 20 years withdrew their offer to sell to interstate pipe line project and are negotiating to sell within Oklahoma.
- Curtailment of pipe line projects indicates loss of construction jobs and loss of huge sales of steel and equipment, which in turn means more jobs lost.
- Transactions involving bank loans on gas reserves which are needed to finance expansion are in jeopardy.
- In La Gloria Producing Company case it is demanded that company supply gas to transmission lines instead of using it for gas repressuring of field to increase cumulative output of field. This could put FPC in direct conflict with state conservation regulations.

Petroleum Industry Mobilizes to Fight Wellhead Price Controls of Natural Gas

Committee of 500 from all branches organize to free independent gas producers from FPC regulation imposed by Supreme Court decision

ERNESTINE ADAMS

THE petroleum industry is mobilizing to fight for its life as a free economic agent.

Result of a U. S. Supreme Court decision implemented by Federal Power Commission directives has put natural gas producers in the same class as public utilities, even to requiring control of wellhead gas prices. At first the petroleum industry was stunned, then work of industry leaders culminated in the formation of a General Gas Committee of some 500 members from all phases of the industry.

This committee held its first meeting and a press conference at San Antonio, Texas, in October, prior to the annual meeting of the Texas Mid Continent Oil and Gas Association.

Maston Nixon of Corpus Christi, Texas, president of Southern Minerals Corporation, is general chairman of the committee; Charles H. Murphy, Jr., Murphy Corporation, El Dorado, Arkansas, is vice chairman, and R. F. Windfohr, Fort Worth, heads the steering committee.

The industry and its friends were beginning to realize the full impact of the fateful decision in the Phillips case, which left the natural gas producer who sold to interstate transmission lines under control of the Federal Power Commission. There was a strong belief that if the matter was not corrected by Congress, the entire petroleum industry was headed for nationalization.

In an unscheduled speech at the Texas Mid Continent meeting Senator Lyndon Johnson (D. Texas) said that the petroleum industry was at the crossroads and one path led to governmental control. The Phillips case, which he called "shockingly wrong," was decided, Johnson said, in the face of obvious Congressional intent that gas producers should be exempted from FPC control; in the face of all precedent set by other decisions, and in the face of FPC's own recent decision that it had no jurisdiction.

Chairman Nixon said the committee will seek Congressional action to correct the present confused situation. Federal price fixing, he pointed out, has no place during peace time in a competitively operated, risk-taking business.

Harry W. Bass, independent operator and president of Texas Mid-Continent Oil and Gas Association, said that "whether our business retains its freedom or is gradually absorbed into a socialistic state," depends on the outcome of the controversy caused by the

EXCLUSIVE

J. C. Donnell, II, Ohio Oil Company, warned that regulation of competitive prices implied grave consequences to the American concept of economic freedom.

Phillips case decision. Bass stated that federal price fixing of natural gas prices "leads inevitably to federal yardsticks for prices of liquid products, eventually to crude oil and gas sold intra-state as well as interstate."

Socialization Seen

Bass' conclusion was that present interpretation of the Natural Gas act would result finally in "the socialization of private property in one section of America for the benefit of voting masses in another section."

Interstate pipe lines were represented at the San Antonio meeting by George T. Naff, president of Texas Eastern Transmission Corporation. He explained that whether the produced substances were gas or oil, the transporting agency is nothing but a link between the well, the refinery, or the gasoline plant and the market. Its income depends not on the purchase and resale of oil or gas but upon the investment in the transportation facilities devoted to the service.

As the connecting link, Naff said, the transmission companies must assure a proper balance between supply and demand—must be able to purchase gas and sell it to the distributors at a price which will be competitive with other fuels.

Case Not Made

The pipe line president pointed out that many distributors held the view that price fixing was their safest solution and that it was important to meet this belief with a reasoned approach. "The case has not yet been made by the petroleum industry," he said.

"Long range future of the interstate natural gas business lies in an abundance of supply and not in measures which may diminish that supply year by year," Naff stated. "The investment required for the long distance transportation of gas is so enormous that a supply of gas for many years is necessary before a project can even be considered, much less certificated and financed. The maintenance of this supply requires additional reserves as the population of the area increases. Thus continuing the supply at a static rate is not sufficient.

"There must be incentives for additional development and for thorough exploration. This can be done, as I see it, only through permitting the producer to enjoy his discovery value in competition with all other producers. It cannot be accomplished through a utility concept of regulation," Naff said.

Consequences of applying public utility regulations to natural gas producers were discussed by J. C. Donnell, II, president, The Ohio Oil Company. A summary of the points brought out by the Donnell speech were:

1. Regulation of competitive prices in oil and gas production would be a radical departure from the basic principles of our nation. It implies the gravest consequences to all our competitive industries and the American concept of economic freedom.

2. Enforcement of the court's recent construction of the Natural Gas act will bring the FPC into conflict with state conservation agencies with producers caught in the middle.

3. A public utility is given the exclusive privilege of providing a service or commodity, and in exchange gives up its freedom to set its own rates. In the case of natural gas production no such exclusive privilege can be granted so regulation of rates would not be proper.

4. Producers may be forced into accepting limited earnings from currently producing reserves as better than no earnings, but they will not gamble large sums in drilling 9 exploratory wells in the hope that they will be permitted to earn 6 or 7 per cent on the investment in the one successful well which they may obtain on the average. One might just as well expect a man to bet a dollar on each of 9 horses in a race, when he knew that the most he'd get back would be $1.06.

5. One-third of current natural gas production is obtained from oil wells and is known as casinghead gas. Any formula applied to allocate cost and expenses of producing different hydrocarbons from the same well would necessarily be arbitrary and would tend to restrict the earnings of the producer from all of the production from the well.

6. If the federal government regulates the price of gas coming from a well, it will not be long before there will be a demand from some groups to

U. S. Fuels Report Due December 1

President Eisenhower's cabinet committee on natural gas, petroleum and coal is to make a report December 1 with recommendations for future policies on U. S. fuels.

The cabinet committee is headed by Mobilization Director Arthur S. Fleming. Members are Secretary of State John Foster Dulles, Defense Secretary Charles E. Wilson, Attorney General Herbert Brownell, Jr., Secretary of Interior Douglas McKay, Secretary of Commerce Sinclair Weeks, and Secretary of Labor James P. Mitchell.

Joseph L. Fisher, former assistant to the president's Council of Economic Advisers, is staff director of the committee's task force.

J. Ed Warren, past president of the Independent Petroleum Association of America, has taken the post of head of the oil and gas task force of the committee. Formerly from Midland, Texas, Warren is on leave as vice president of the National City Bank of New York.

Consultants helping him include Richard G. Gettell, chief foreign economist, The Texas Company; Richard J. Gonzales, treasurer and director, Humble Oil and Refining Company; Minor S. Jameson, Jr., assistant to the president, IPAA; Serge B. Jurenev, assistant to the chairman of the board, Continental Oil Company, and C. Pratt Rather, president, Southern Natural Gas.

It is speculated that the committee may have specific recommendations on the legislation to free independent gas producers from FPC control. The U. S. Supreme Court's reversal of the historic interpretation of the Natural Gas Act is considered to be one of the reasons for appointing the top level committee.

Imports are another problem before the committee but, despite the fight of domestic producers and the coal industry, it is thought that imports may be practically ignored because the President is said to feel any ban on imports would hurt his foreign trade policy.

regulate the price of the liquids produced with the gas. If crude oil and natural gas prices can be regulated, then how can coal escape? It competes with oil and gas for the same energy market.

7. Withdrawals of gas from known reserves in recent years have increased by almost 10 per cent. Reserves have dropped since World War II from more than 35 to about 20 years' supply. Transmission lines must have a 20-year reserve backlog in order to obtain Certificates of Convenience and Necessity, and to attract the capital needed to provide facilities for transporting the gas to market.

Political Intervention

In his address on "Energy Markets in a Changing World," P. C. Spencer, president, Sinclair Oil Corporation and Chairman of the Board, API, warned of "unsound and unjust marketing conditions caused by unwise political action." He said that in the case of natural gas, political intervention rather than technological development is reported to have resulted in a competitive price advantage over oil of approximately five to one on a wellhead basis.

"This is an unnatural and uneconomic condition," Spencer said, which in the end will benefit no one, including the consuming public."

Spencer was referring to the fact that the price of gas at the well, for example, is about one-fifth the average U.S. price of crude oil on a Btu basis, and about two-fifths the price of coal at the mine.

The Federal Power Commission is also having its troubles on the other side of the red tape and price control situation. The Commission asked Congress for $300,000 to enforce orders, a request which was turned down. Now it is swamped with 5000 applications from producers in answer to its request for rate data. How these papers will be processed is an unanswered question so far.

TIPRO Objects

Any FPC decision to disallow prices escalated above the starting rate in wellhead sales contracts for natural gas "would constitute a seizure of private property without due process of law," Texas Independent Producers and Royalty Owners Association said in a formal statement.

Signed by Jack Woodward, president of TIPRO, the association asked to be heard at the November 4 meeting of FPC, stating: "The escalation provisions are as much a part of the contract itself as the initial price. In most cases the gas would not have been committed at all except for such provisions."

Let the Consumer Know!

THE consumer must know the facts about how he gets natural gas in his home and what he pays for, K. S. Adams told the American Gas Association at its annual meeting.

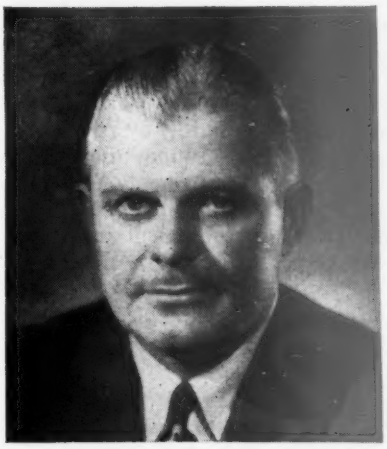
The chairman of the board of Phillips Petroleum Company said:

"What facts do your customers need to know? They need to know, first, that the true effect of federal regulation of producers will be to gradually close the valve on their natural gas supply line. When told the facts they will understand why federal regulation will stifle production of natural gas. They will understand that natural gas exploration and production are absolutely dependent upon individual initiative and the competitive risking of huge investments; that this initiative and risk can be influenced and harnessed only by an incentive—the kind of incentive which is immediately destroyed by remote bureaucratic regulation.

"Does your customer know that in the gas producing business, no one producer has a monopoly such as the distributor is granted in a city? On the contrary, there are thousands of producers, each competing vigorously in leasing, drilling, producing and marketing activities. Does your customer know that the gas producer's prices are really determined by free competitive bargaining in the fullest sense between purchasers and sellers, the same as found within all other producing industries which have no sheltered market? Before an interstate pipeline project takes shape and is laid to receive gas from a particular underground reservoir, those proposing it are free to choose among several prospective gas fields and bargain with all or any part of the owners of gas in those fields. More often than not it is the producer who is under the greatest bargaining pressure.

"Many of your customers are under the illusion that federal regulation is essential to hold their gas costs down. I doubt that 5 per cent have any idea that the price the producer receives for his gas is on the average less than 10 per cent of their bills.

"The consumer needs to know that by far the larger portion of his gas bill is payment for the investment in the construction and for the maintenance and operation of federally regulated interstate pipelines



K. S. Adams told gas men to give consumers the complete and correct story—immediately, forcefully and incessantly.

and locally regulated city distribution systems. He needs to know the facts as to his own bill. For example, in Milwaukee the average residential user paid $1.21 per thousand cubic feet for gas which cost the distributor 31.8 cents for which the pipeline paid the producer only 8.7 cents. Your New York customer might be astonished to know that according to latest available figures only about 3 per cent of his gas cost goes back to producers as payment for their costs and financial risks in supplying him gas.

"These facts make clear that any appreciable reduction in the supply of gas you handle—sure to come under federal regulation of producers—will raise the consumer's gas price far more than he could realize as savings from a drastic cut in the field price. His hope for any sizeable reduction in his gas cost lies in having a greater supply moving through your distribution system.

"It is my guess that many of you have hesitated to tell your customers such facts, fearing their reactions to the knowledge that your charges make up most of their bill. This fear is groundless, for you have nothing to hide. Because your business is a public utility, your local or state regulatory agency protects your customers by limiting your rates according to your earnings. You have everything to gain by informing your customers of the facts; you stand to lose everything if they are not sufficiently informed to demand Congressional action which will remove this threat to their gas supply and their pocketbooks."

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Gas Supply in Danger

One of the most powerful arguments so far set forth was made by K. S. Adams, chairman of Phillips Petroleum Company before the American Gas Association. Some excerpts are carried on page A-57. The address was delivered under the title, "Will Distributing Companies Sit Idly by While Federal Regulations Sound the Death Knell to Their Gas Supply?" To the pipeline transmission companies, gas appliance and equipment manufacturers and gas distributors, Adams said:

"To you, it means a reduced volume of business. It means the death blow to your future gas supply. Where will your present volume come from, let alone the additional quantity you desire, after the dwindling supplies in the underground reservoirs now serving you are gone?

"To gas appliance manufacturers and dealers, it means the loss of sales of untold numbers of kitchen ranges, heaters, furnaces, water heaters, clothes driers, and other gas-burning equipment.

"It means less gas for commercial and industrial purposes. It means a further decline in the economy of the older industrial areas as the recent movement of the manufacturing industries to gas-producing states is accelerated."

News Coverage

Another point brought out in the Adams' speech was that news writers, columnists and others more often than not have, intentionally or through ignorance, mis-stated the issues and misled the public. This has been demonstrated in recent days.

Following the speech by Phillips' chairman in Atlantic City the New York Times quoted James F. Oates, chairman of the Peoples Gas Light and Coke Company, as saying that the public interest involves straightforward regulation by the federal government and state utility commission.

In a statement released at the close of the convention, Oates denied the newspaper report that he favored federal and state regulation. He said that he agreed with the position taken by Adams in his speech.

"We believe, as a matter of economic principal, that production of all natural resources, including natural gas, should be free from regulations," Oates said.

So we have rumors that some transmission companies, that some distributors, and that some eastern financiers are in favor of regulation of gas prices at the wellhead and that they will oppose Congressional action to clarify the Natural Gas act. Most of these rumors, however, resolve themselves into political lines and concern generally those people outside the petroleum industry who are not informed. No one who knows anything about the petroleum industry is naive enough to believe that plentiful supplies of natural gas can be obtained under rigid 20-year contracts with all the headaches of federal red tape, for the same profit that can be made by putting the money into utility company stock!

E. A. Landreth

Edgar F. Bullard

RECEIVE DISTINGUISHED SERVICE AWARDS

E. A. Landreth, Fort Worth independent producer and Edgar F. Bullard, president of Stanolind Oil and Gas Company, have received the Texas Mid Continent Oil and Gas Association's Distinguished Service Awards for 1954. Awards were presented at the 35th annual meeting in San Antonio, Texas.

Landreth came to Texas from Missouri and developed his first oil properties in 1918 at Breckenridge.

Following discovery of the Rowan and Tong field, West Texas, in 1927, Landreth drilled 7 wells in the area, all dry holes. His estimated losses from the venture topped the $5,000,000 mark. He kept on and recouped with 16 good wells.

In 1938 he sold his West Texas properties and arranged for key employees of the Landreth Corporation to buy stock in the firm. Four years later he organized the Landreth Company, which he serves as chairman of the board.

Landreth has given freely of his time and money to educational and youth development activities. He has been a trustee of Texas Christian University since 1940.

Bullard, a native of New York, joined Dixie Oil Company in 1921 following graduation from Yale with a degree in geology. He was made director of exploration for Stanolind in 1931 and since that time has played an active part in virtually every phase of the company's development. He became vice president in 1932 and executive vice president in 1935. He assumed the presidency of Stanolind in 1945.

Bullard is known in industry circles as an unexcitable, "long range" thinker, and excellent administrator. He has been a strong advocate of oil field conservation programs and has always been an enthusiastic ally of geophysics.

Aside from running Stanolind, Bullard serves as president and director of 15 other oil and gas enterprises, from Texas to Canada.

Conclusion

Price fixing has been tried repeatedly and always the burden is on the consumer. During the rule of the Office of Price Administration there was rationing, scarcities, black market, and low quality goods when prices were set too low. Too high prices bring buyer resistance and disrupting surpluses.

If prices are set by the FPC on a Btu basis as competitive with coal and oil, natural gas would be increased in cost.

The most important factor is that this nation get full benefit from its energy sources in order to meet the skyrocketing energy demand. This is impossible with a part-free, part-controlled energy market. Price is the keystone of efficient development and utilization. A controlled price among those arrived at by supply and demand would upset the balance needed to find the best use for each type of energy.

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BZ-80-A

Exploration, Drilling, Producing

Oil at Magnetic Pole?

Is there oil in the frozen wastes around the magnetic pole? A scientific staff headed by Rev. Daniel Linehan, director of the Boston College seismograph station, thinks there may be. The expedition has completed an 8000-mile voyage, during which seismograph tests were made on Prince of Wales Island and at Emily Bay, where indications of oil were found.

★ ★ ★

Arrow Sells Stock

British Empire Oil Company, Ltd., Calgary, Canada, has acquired all outstanding stock of Arrow Drilling Company of Tulsa, Oklahoma. Acquisition combines the extensive land holdings of British Empire in British Columbia and Alberta and in the Williston Basin of the U. S. with Arrow, a major drilling company, operating principally in Texas, Oklahoma, Louisiana, and Canada.

★ ★ ★

SEG Safety Award

The Society of Exploration Geophysicists was one of the 11 trade associations presented with the National Safety Council's award during that organizations 42nd annual meeting in Chicago during October. The citation was for outstanding work in promoting safety in small business.

★ ★ ★

Company Change Made

Reorganization of Stanolind Oil and Gas Company's exploration districts in a move to strengthen its exploration program has been announced by F. J. Schempf, vice president of exploration. Arrangement calls for establishing the position of district exploration superintendent in those exploration districts where the size and scope of operations warrant. Men designated as district exploration superintendents will have jurisdiction over all geological, geophysical, and land operations within their respective districts. In other districts, either the district geologist or district landman will function as the top man in addition to his other duties. Program became effective on November 1.

Schempf pointed out that the move is a further step in the company's program of decentralization operations, which was begun several years ago.

Mafia Island Test Well

Preparations are being made for the drilling of a test well on the thinly populated island of Mafia, off the coast of Tanganyika, according to an Anglo-Iranian Oil Company announcement. Well will be drilled by the D'Arcy-Shell Petroleum Company of Tanganyika, a joint enterprise of the Anglo-Iranian and Shell Groups, which has been carrying out geological and geophysical surveys over wide areas of East Africa since 1951. The test well, on which the platform for a 136 ft high drilling rig is nearly completed, may be drilled to a depth of 12,000 ft.

★ ★ ★

Research Lab Enlarged

The Carter Oil Company, Tulsa, Oklahoma, has recently dedicated enlarged research laboratories. A new 2-story wing increases main laboratory facilities by 50 per cent. There is also a new 6-story high drilling research tower, a new chemical service unit, and a warehouse.

The staff of the Carter laboratory and shops now numbers 220 scientists and technicians, according to President Brice, who are endeavoring to discover more effective means of finding oil fields and improved methods of producing them to obtain maximum recoveries.

★ ★ ★

Buys Into Cuban Field

Cuban-Canadian Petroleum Company of Cuba, a wholly-owned subsidiary of the American Leduc Petroleum Company, Ltd., of Edmonton, Alberta, has purchased a 50 per cent interest on a checkerboard basis in the Echeverria field, first commercially-productive oil field in Cuba. The rights, covering 6000 hectares (15,000 acres), were acquired from Petroleria Jatabonico, original grantees of the concession in Camaguey Province.

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Gulf of Mexico Exploration

Two Gulf of Mexico exploration programs has been announced. Pure Oil Company, Sun Oil Company, and Seaboard Oil Company have signed an agreement to search for oil in the Texas Gulf, and a similar agreement has been made by Pure, Ohio, and Sun for the Louisiana Gulf area. Pure is doing the geophysical work.

Kansas Oil Meeting

Kansas Oil Men's Association has announced that its 40th annual meeting will be held January 12 and 18, 1955. Baker Hotel in Hutchinson, Kansas, will be the site of the meeting.

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Israel Drilling Begun

Drilling for oil in Israel has begun with a test well scheduled for a depth of 8000 ft. The well, Tell-Es-Safi No. 1, is being drilled 17 miles southwest of Jerusalem by Israel-Mediterranean Petroleum Company and Pan-Israel Oil Company, American-backed companies that have oil concessions covering more than 800,000 acres. The drilling contractor is Pantepec Oil Company, C. A., a Venezuelan company that operates in Israel through its wholly-owned subsidiary, Tri-Continent Drilling Company.

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Gas Flaring Prohibited

An order prohibiting the flaring or venting of casinghead gas at approximately 2500 wells in Lea County has been issued by the New Mexico Oil and Gas Commission. Order was effective November 1 and is the first such issued by the state. Order also prohibits flaring of gas at gasoline plants.

About 95 per cent of the gas in the affected fields is being marketed, and the new order is being directed against the 5 per cent waste, according to William B. Macey, commission director.

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PGCOA to Hold Meeting

The Pennsylvania Grade Crude Oil Association will hold its 1955 annual meeting next June 9 and 10 in Hotel William Penn, Pittsburgh, according to a recent decision by the board of directors.

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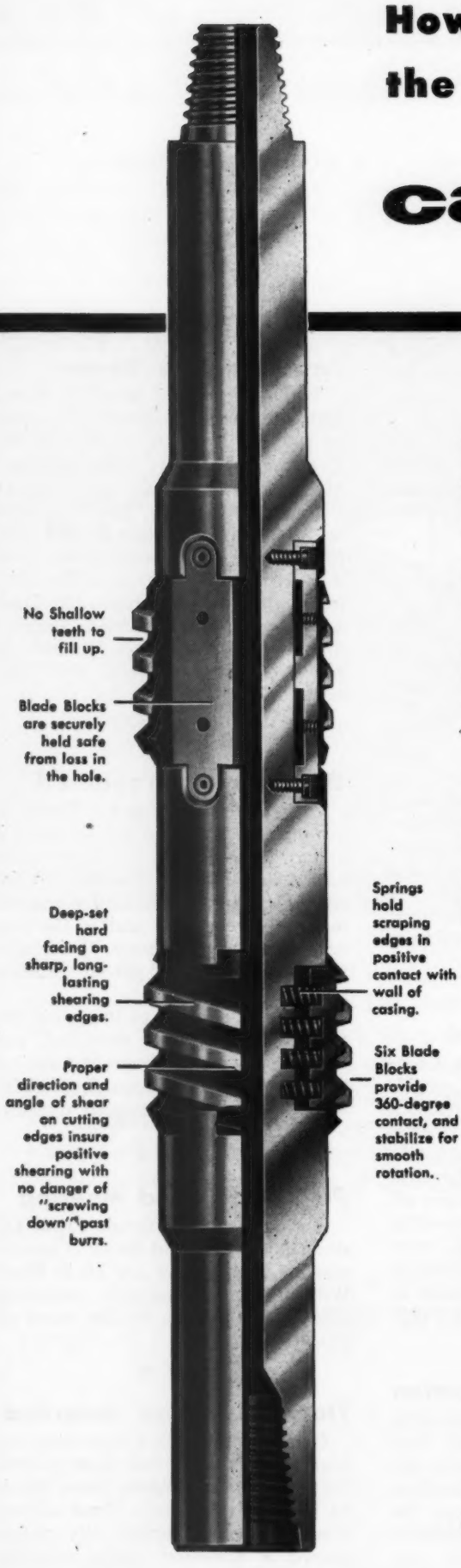
Tidelands Lease Awarded

General Petroleum Corporation has been awarded a 10-year lease to drill for oil on tidelands within Santa Monica, California city limits. Lease will not become effective unless city voters rescind a provision which presently prohibits the location of oil wells anywhere within city boundary lines.

How important is it to have the inside of your

casing smooth


No Shallow teeth to fill up.
Blade Blocks are securely held safe from loss in the hole.
Deep-set hard facing on sharp, long-lasting shearing edges.
Proper direction and angle of shear on cutting edges insure positive shearing with no danger of "screwing down" past burrs.
Springs hold scraping edges in positive contact with wall of casing.
Six Blade Blocks provide 360-degree contact, and stabilize for smooth rotation.

Not only is it important to have clean casing *when a well is being completed,* but consider also the advantages of being able to *proceed safely with any future down-hole work,* knowing that the vital "working surface" (the I. D.) of your casing is *clean and free of all obstructions.*

Hardened mud or cement, burrs from gun-shot perforations, and even mill scale are all hazardous when you run testers or swabs, or undertake to set cement retainers, bridge plugs or packers.

With a Baker Model "C" ROTO-VERT Casing Scraper you can quickly, safely and economically remove harmful obstructions from the inside of the casing, leaving it clean and smooth for any future down-hole operations.

RUN A ROTO-VERT WHEN DRILLING OUT

The best time to use a ROTO-VERT Casing Scraper is when drilling out cement, by running it as a "follow-up" behind the bit. It is recommended that the ROTO-VERT first be lowered through the perforated area *without rotation,* to dislodge any possible imbedded bullets; then raise the Scraper above the perforated area and rotate down the hole and complete the work of drilling out cement. In a *single run* you not only "drill out", but at the same time remove all hardened cement, mud, burrs and scale which might otherwise later *damage swab or tester rubbers* and cause packers, bridge plugs or retainers to *set prematurely*—or *never set at all.*

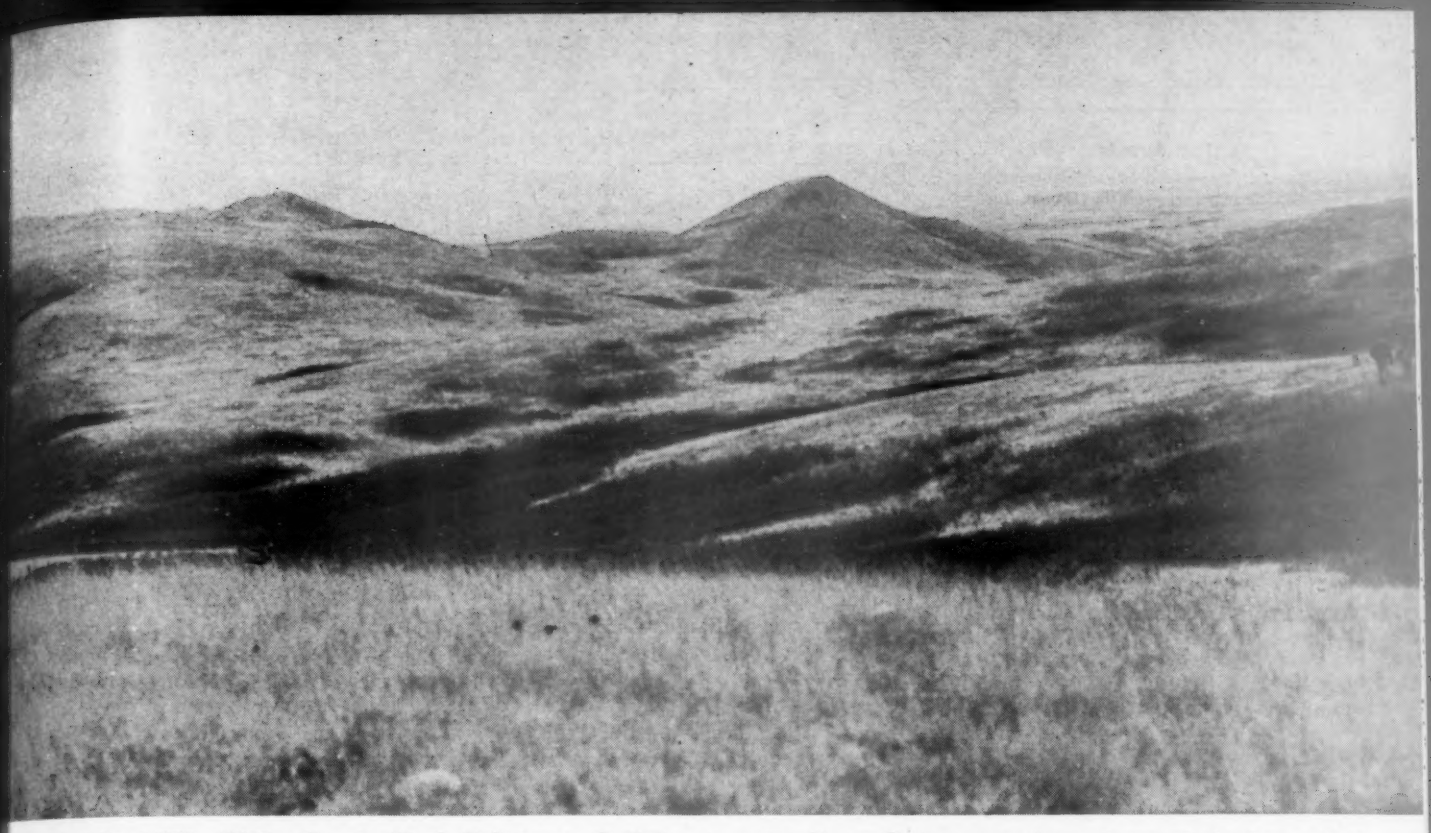
ROTO-VERT SUPERIOR IN DESIGN AND PERFORMANCE

No other casing scraper can equal the results obtained by the Baker ROTO-VERT, because . . .

1. The *direction and angle of shear* of the cutting edges is OPPOSITE TO THE DIRECTION OF ROTATION. There is no possibility of "screwing down" past obstructions during rotation;
2. The shearing edge of the Blades on the ROTO-VERT is set at *only a slight angle from the horizontal.* This minimizes torque and vibration, and places far less strain on the Blade Blocks and the entire assembly;
3. The six rugged Blade Blocks are positioned to overlap for full 360-degree scraping coverage.

For consultation and service on Baker ROTO-VERT Casing Scrapers...

call BAKER



Horsehead Hills, Kidder County, North Dakota, are faulted outcropping Upper Cretaceous rocks, and one of the few surface structures on the Williston Basin east flank. Even here the geology is partly obscured by glacial drift cover.

P 111.5

Williston Exploration and Geology

Thick glacial drift and unconformities of east side of basin make slim hole drill best discovery tool

DONALD TOWSE

OIL men are looking optimistically to the shallow east side of the Williston Basin and putting their money on the line in hopes of finding more good production at shallow depths. It was on the east flank at Virden in Manitoba where oil was first discovered in the basin early in January 1951. More than 75 wildcats have been drilled in the long trend in North Dakota alone since Williston activity began, and many more are being planned. Some good potential fields have been developed in Canada in the last three and a half years, and three small fields have been discovered in Bottineau County, North Dakota.

East side exploration is difficult and often frustrating. Surface geology is of little use due to a thick cover of glacial drift, the thin sedimentary column makes gravity and magnetic interpretation difficult, and the drilling of good seismograph prospects has proved disappointing. It is the many unconformities there, the obscure facies changes, and the onlap-offlap relationships that both has made exploration difficult and that makes the whole region a potential oil province.

Basin geologists say that they could make an animated cartoon of the maps and sections they have been constantly changing since 1951. Most of the wildcats to date must be considered stratigraphic tests, and many correlations and interpretations still must be carried over untested distances of 15 to 50 miles. Each area of more intense drilling uncovers more irregularities of structure and stratigraphy, and the early simple and featureless face of the Williston Basin becomes more wrinkled with age.

EXCLUSIVE

With the increased information, the stratigrapher and the subsurface geologist are beginning to find the answers and the information that will unlock the oil fields that must lie on the Williston Basin's east flank. Conditions known from Canada and the northern part of North Dakota are being extrapolated to other areas, and geologic imagination has an increasing fund of information on which to build. The normal may now be predicted, and each new stratigraphic test is watched as either a potential new producer or a guide to a possible subsurface prospect.

The "east side," as it is understood locally, includes southwestern Manitoba, North Dakota east of the Missouri River, and north-central South Dakota. More drilling and additional discoveries are confidently expected due to the increased geologic knowl-

The Author

Donald Towse is a consulting geologist in Grand Forks, North Dakota. He was educated at M.I.T., where he received B.S. and Ph.D. degrees. Towse has taught at M.I.T., the University of North Dakota, and was a geologist with Amerada Petroleum Corporation in Wyoming and South Dakota before moving to North Dakota in 1951. He did part-time consulting work in the Rocky Mountain area before recently devoting full time to consulting.

edge and the favorable economics of shallow and slim-hole drilling.

Production

Oil production in Manitoba has been held down due to lack of market and pipeline outlet. Development drilling has gone ahead, but wells have been shut in as completed. Production through April 1954 totalled 1,266,745 bbl, and 492,766 bbl of the total were produced in the first 4 months of 1954. First discovery in Manitoba was in the Virden area, and the province's major fields, Daly, Virden, North Virden, and Roselea are all in that area.

Daly and Virden field produce from Mississippian Lodgepole limestone at about 2500 ft. Initial production varies from 10-bbl pumpers to wells flowing 150 bbl per day. Production is mainly from a crinoidal zone about 100 ft below the top of the Mississippian. The Roselea area to the east produces from crinoidal Lodgepole at depths around 2000 ft and about 50 ft below the top of the Mississippian. Initial flowing production has been as high at 2500 bbl per day.

Most completions are open hole in the Virden field, although a few produce through perforations. Some wells have been acidized or fractured. Water is a problem in the smaller wells, but not enough production history has been accumulated on any of the fields to predict future behavior.

Three fields on the North Dakota east side, all in Bottineau County, were discovered in 1953. They lie close to the Canadian border where similar production has been established nearby in Manitoba. Total production in Bottineau County through April 1954 was 28,103 bbl. Production in the first 4 months of 1954 totalled 6173 bbl, and 7 wells were producing in April. Production is at the top of the Mississippian Charles or Mission Canyon formations at depths from 3000 to 3350 ft, and initial pumping production ranged from 6 to 65 bbl per day. Average daily production during May ranged from 3 to 20 bbl per well, but some wells are not capable of producing every day. A few of the wells make large quantities of water with the oil. Bottineau County has recently been granted an increased allowable by the State Industrial Commission, and production may increase slightly.

TABLE 1. Typical drilling depths to objective formations.

	Charles	Mission Canyon	Lodgepole	Devonian	Silurian	Red River	Winnipeg	Precambrian
Virden, Man.	....	....	2200	2500	4250	4750	5200	5350
Bottineau Co., N. D. (north)	3000	3100	3300	3900	5100	5600	6170	6400
Bottineau Co. (south)	3850	4400	4670	5380	6600	7240	7870	8250
Burleigh Co.	3870	4340	4470	5000	5300	5850	6500	6950
Rolette Co.	....	....	2576	2800	3760	4200	4770	4950
Ramsey Co.	....	....	....	2150	2600	2950	3475	3730
Stutsman Co.	....	....	2010	2280	2360	2540	3100	3430
Dickey Co.	....	....	....	....	....	1520	1630	1880

Exploration

The eastern flank of the Williston Basin was recognized as a potential oil province because of the existence of a wide wedge belt of porosity long before serious exploration began. A. I. Levorsen pointed out the possibilities of wedge belts in 1931 and 1933, and the following paragraph appeared in the AAPG symposium on possible future oil provinces in 1941.

"From west to east across both of Dakotas, there is a gradual loss of sedimentary section, either by truncation and overlap or non-deposition to the Minnesota border, where Cretaceous to Jurassic rocks rest unconformably on rocks of Devonian to Precambrian age. Due to this eastward overlap, there must be several large wedge belts of porosity extending throughout much of the 400-mile distance from north to south."

The wedge edge was again pointed out in a map by Levorsen in 1943. First United States activity came when Union Oil Company made a large lease play in the Cavalier-Ramsey counties area and then drilled a test in Ramsey County in 1949. In the same year Continental and Pure began to evaluate their large holdings in the central part of North Dakota by drilling a well in Burleigh County. Imperial and the California Standard worked in southwestern Manitoba, and in late 1950 California Standard began drilling the discovery well of the Virden field. Small discoveries continued in Canada, and the big play in Bottineau County last year resulted in three small discoveries. The large flowing production established in Roselea early this year has resulted in a second look at the whole pinch-out area.

Dry holes are widely scattered throughout the belt. Most have been stratigraphic tests located on only the slightest regional geologic information. Union's failures in Cavalier and Ramsey counties followed extensive seismic work. Much of the California Standard's success is based on seismic surveys. The Roselea discovery, however, was a stratigraphic test. Other attractive seismic prospects in the wedge belt proved dry. Ground magnetometer surveys by the North Dakota Geological Survey are difficult to interpret geologically, and they have little relation to seismic results. Magnetic anomalies are apparently caused by lithologic changes in the shallow basement rocks. Union did some structure drill work in Cavalier County last year, but no sustained program of structure drilling such as has been carried on in Alberta has been attempted.

Readers familiar with flank areas in Texas and Kansas are asked to note the small scale of the accompanying maps. Except for a few scattered areas, density of drilling is quite low, and many scarcely tested and possibly anomalous areas remain. Present exploration continues to use the drill. An active drilling campaign is presently in progress and may make these maps and this report old in the near future. The southern part of North Dakota and most of South Dakota is hardly touched. Wells already planned and others not yet announced may remedy this before the year is over.

Due to the shallow to moderate depths to objective horizons in the region (Table 1), light jack-knife type rotary rigs are used. In the extreme east, truck mounted drills with a 2000 to 2500-ft capacity are used. Attempts at drilling with cable tools have failed because of the thick section of caving shale near the surface. Some wells have been completed with cable tools. Little serious drilling trouble is encountered. Lost circulation is sometimes a problem in the Devonian and Silurian vulgar beds, but it is usually controlled. The Winnipeg sands in southeastern North Dakota have moderate water pressure and have occasionally blown out, but that can now be anticipated and controlled by proper mud weights. Salt and anhydrite are not a problem in most of the region as they are in the deeper parts of the basin.

Some leases are beginning to expire, but many have 5 years to go. The large

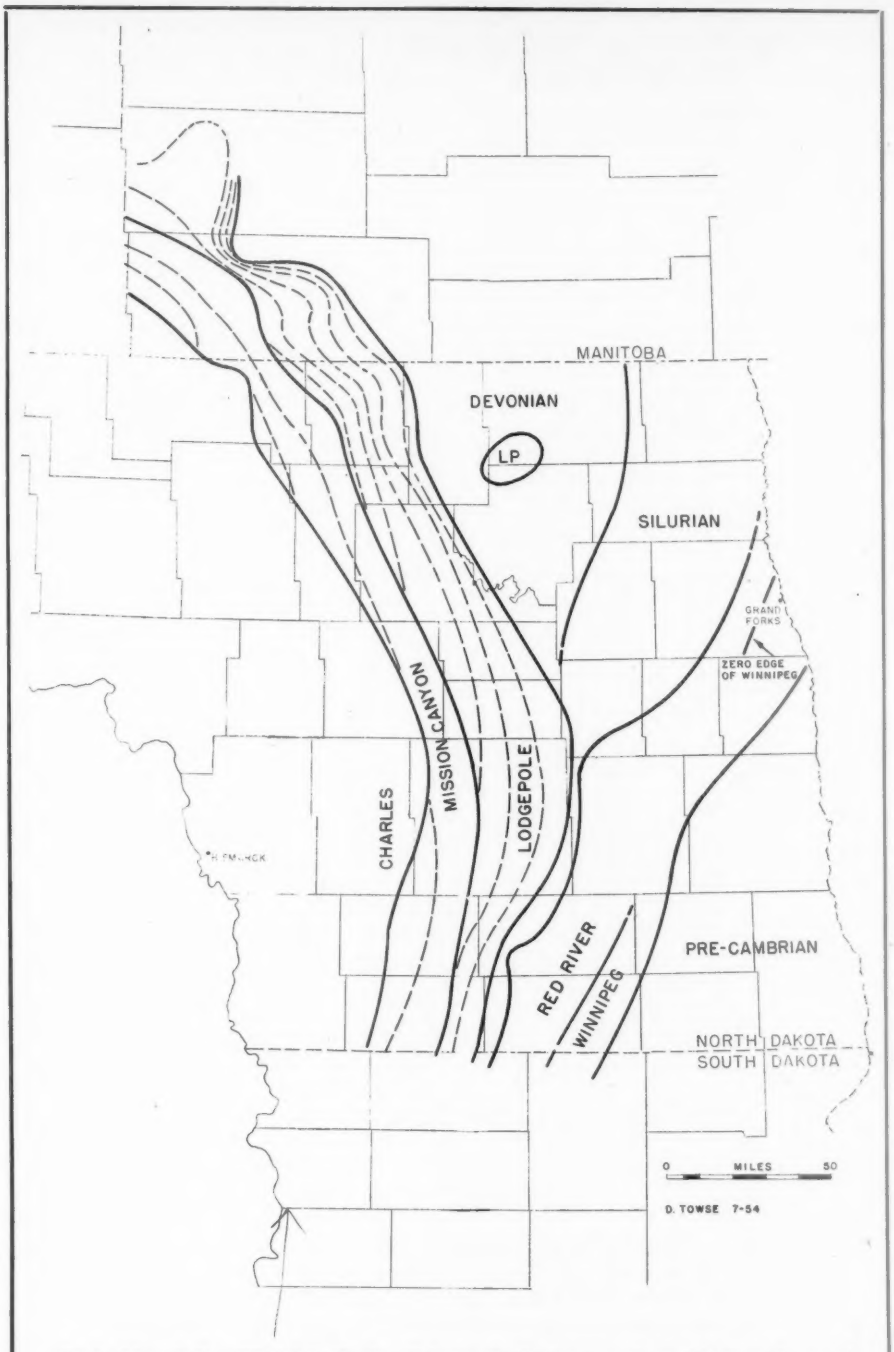
lease holdings of some companies are apparently a burden, however, and numerous farm-out deals have been made. Many major companies have been drilling, but most of the activity has been by smaller companies and independents who have had good major company support. Lloyd Sveen, oil editor of the Fargo (North Dakota) Forum, reports that many of the farmers in eastern North Dakota are becoming discouraged about oil possibilities and that the market for royalties and minerals has slumped. That situation is certainly more healthy than that of three years ago, when crowds visited the drilling rigs, the people expected oil fields in their back yards, and everyone including shoe-shine boys was in on the royalty and lease speculation.

Structure

Regionally, the east side is a structural monocline dipping toward the deeper parts of the basin to the west. Locally the monocline is broken by anticlinal noses and small closed folds. Regional strike changes from nearly east-west in western Manitoba, to northwest-southeast at the international boundary, to nearly north-south in the middle of North Dakota. It swings around to southwest-northeast and eventually to east-west again on the southern rim of the basin in South Dakota.

As most of the region is covered by glacial deposits, surface geology is of little help. Upper Cretaceous rocks are exposed in Emmons County in North Dakota, and there is a low dome in the southern part of the county that was drilled and found dry. Cretaceous rocks show through the drift again in Kidder County, where in the Horsehead Hills sandstones that dip as much as 45 deg to the northeast are exposed for more than a mile. The structure is interpreted as a northwest-southeast trending fault, and it probably extends under the drift-covered hills toward the northwest for some distance. Magnolia drilled a dry hole west of the hills in 1950 after seismic survey. The structure is difficult to interpret exactly by surface geology, and structure drilling is probably necessary to find the answer.

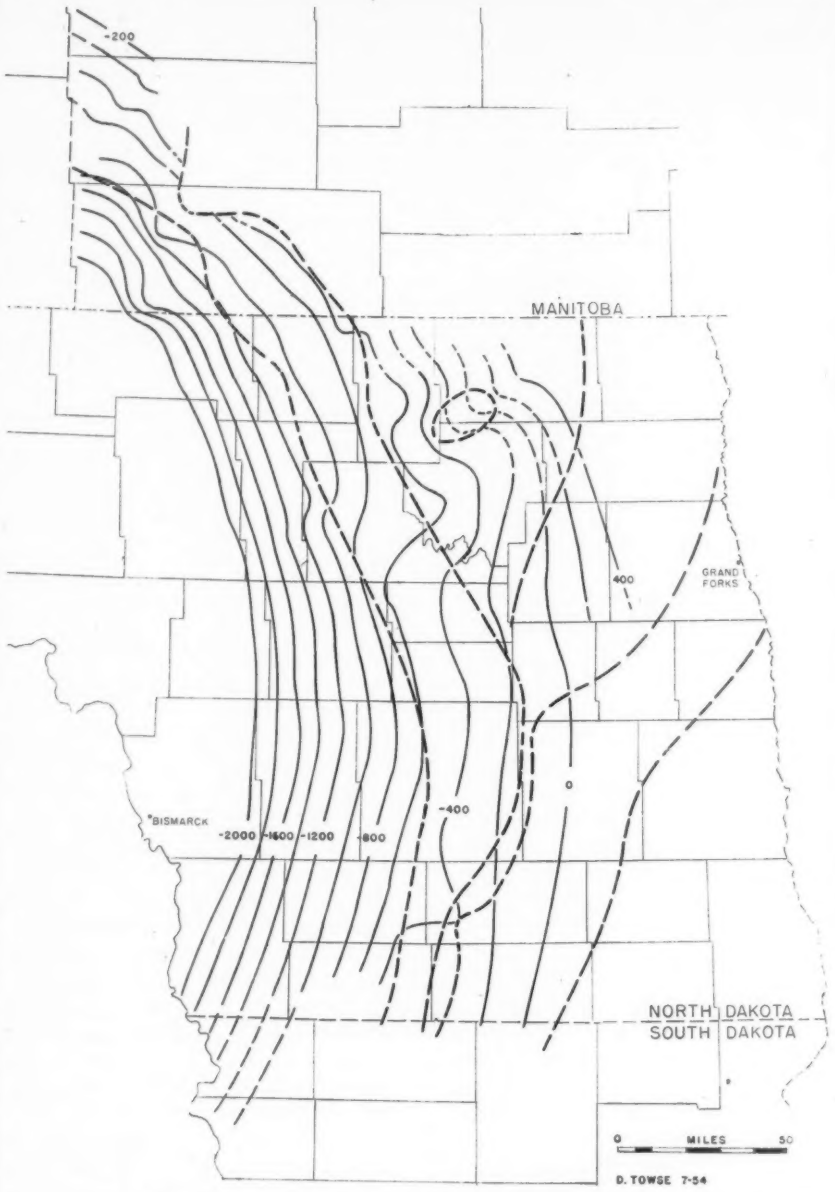
Anomalous steep dips are reported in a few other places where small areas of bedrock are exposed. Steep dips and some faulting are known in probable Tertiary rocks in northwestern Rolette County, and a small anticline near Mohall in Renville County produced a small amount of gas from shallow sands about 30 years ago. The deepest well on the Mohall anticline went no deeper than the Dakota sand, and there has been no recent deep drilling.



East side of the Williston Basin. Paleogeological map of post-Paleozoic erosion surface. Thickness of Mission Canyon and Lodgepole shown by dashed isopach lines, contour interval 100 feet.

Unconformities may be considered to be the major structural features of the east flank. As may be expected, unconformities increase in number and in magnitude toward the basin edge. The major unconformity is at the base of the Mesozoic rocks, where Triassic to Cretaceous rocks overlap, from west to east, Mississippian, Devonian, Silurian, Ordovician, and Precambrian. Most of the present interest is east of the zero edge of the Mississippian Charles formation, where the Upper Mississippian Big Snowy group and the Amsden formation are also missing, and the Mesozoic beds lie on Madison and older rocks. Information developed to date indicates simpler structure in the area where Charles and younger Paleozoic rocks are present. It may be expected that epeiorogenic movements and folding would be more frequent in the basin edge areas.

A few of the east-side tests have been drilled on seismic structures, although most of them were reported to be small. The California Company drilled a dry hole on a good anomaly in Bottineau County, and dips as high



East side of the Williston Basin structural map. Datum: Top of Mississippian Lodgepole or top of Paleozoic limestone where Lodgepole is missing. Contour interval 200 feet. Heavy dashed lines show zero edges of Mission Canyon, Lodgepole, Silurian, Devonian, and Ordovician taken from paleogeological map.

as 45 deg were found in cores of Silurian coral rock and in the Precambrian basement. Most of the beds lay nearly flat. A National Bulk Carriers dry hole was recently drilled on a reportedly good seismograph structure in Benson County. It found a thin Mission Canyon section, and the Lodgepole was structurally high. The general failure of the seismograph to find oil-bearing structures in eastern North Dakota may be due to the post-Paleozoic unconformity and the nature of the sediments. The sediments from the top of the Mission Canyon to the base of the Ordovician Red River are almost wholly limestones and dolomites with a few minor shaly breaks. If, as is probable, some of the significant folding was in post-Lodgepole and pre-Mission Canyon time, the seismograph would find real difficulty in mapping the structure on the top of the Lodgepole, where there is no great physical change in the rocks.

The most readily mappable horizon is the top of the Paleozoic limestones. As shown on the accompanying maps, the top Paleozoic limestones vary from Mississippian to Ordovician in age as they lie under the Mesozoic sandstones and shales. It is difficult to differentiate irregularities due to folding from those due to topography on the erosion surface. The area in which Union did their drilling in Cavalier County is a high topographic area on the unconformity where Devonian rocks are protected by an outlier of Mississippian limestone. If the unconformity surface corresponds to the structure and if the erosional relief is not too great, the seismograph many find structural prospects, but if topography is being mapped, interpretation must be modified accordingly.

Where the Dakota group of sandstones lies close to the Paleozoic surface, structure on the Dakota may reflect topography and structure on the underlying Paleozoic. In one case where abundant water-well control was available, the writer was able to map Dakota structures and to predict the position of the zero-edge cliff of a Paleozoic limestone. In such areas, geophysical or core-drill mapping on the Dakota sandstone may be valuable.

The most reliable structural information to date has come from subsurface information resulting from stratigraphic tests. The accompanying structural map with datum on the top of the Lodgepole formation or the top of the older rocks where Lodgepole is absent shows the regional dip and several anticlinal noses. In the north, the Virden-Roselea area is on a Lodgepole nose. Detailed mapping in the fields indicates some local closure, but the regional control is plain. Farther south, on the Canadian border, another Lodgepole nose controls the area of oil production in the border area of Manitoba and in Bottineau County, North Dakota. Farther south in Benson County, recent drilling indicates the presence of another anticlinal nose with a similar northeast-southwest trend. No production had been developed there at the date of this writing. Closer drilling on any of those structures may reveal more local closure and other porosity traps and oil production. Farther south on the flank, drilling is too scattered to indicate positively other folds.

Structural maps on a Mission Canyon datum by the writer and others fail to show the structure here mapped on the Lodgepole. This suggests that there was a period of gentle folding at the close of Lodgepole time. Such an interpretation fits in with the known transgressive character of the Lodgepole and the off-lap of the Mission Canyon in post-Lodgepole time.

The pattern of Paleozoic formations and the swing in regional strike in southeastern North Dakota suggest that an intelligently directed program of drilling there should uncover other structures similar to those in the north. No faulting is known to the writer, but by analogy with other subsiding basins, normal faulting may have occurred on the basin periphery.

Stratigraphy

Several generalizations may be made about the rocks as they rise eastward out of the center of the basin. All formations thin by non-deposition, and unconformities become larger and more numerous. Sandstones become coarser and thicker in the Mesozoic, and Ordovician Winnipeg sandstones are coarser and more porous than in the basin. The most striking changes are in the limestones and dolomites. All formations contain more fragmental material, dolomite becomes more common, and there is less salt and anhydrite. Limestones and dolomites are lighter in color, have more primary and secondary porosity, and red to brown shale beds are more common.

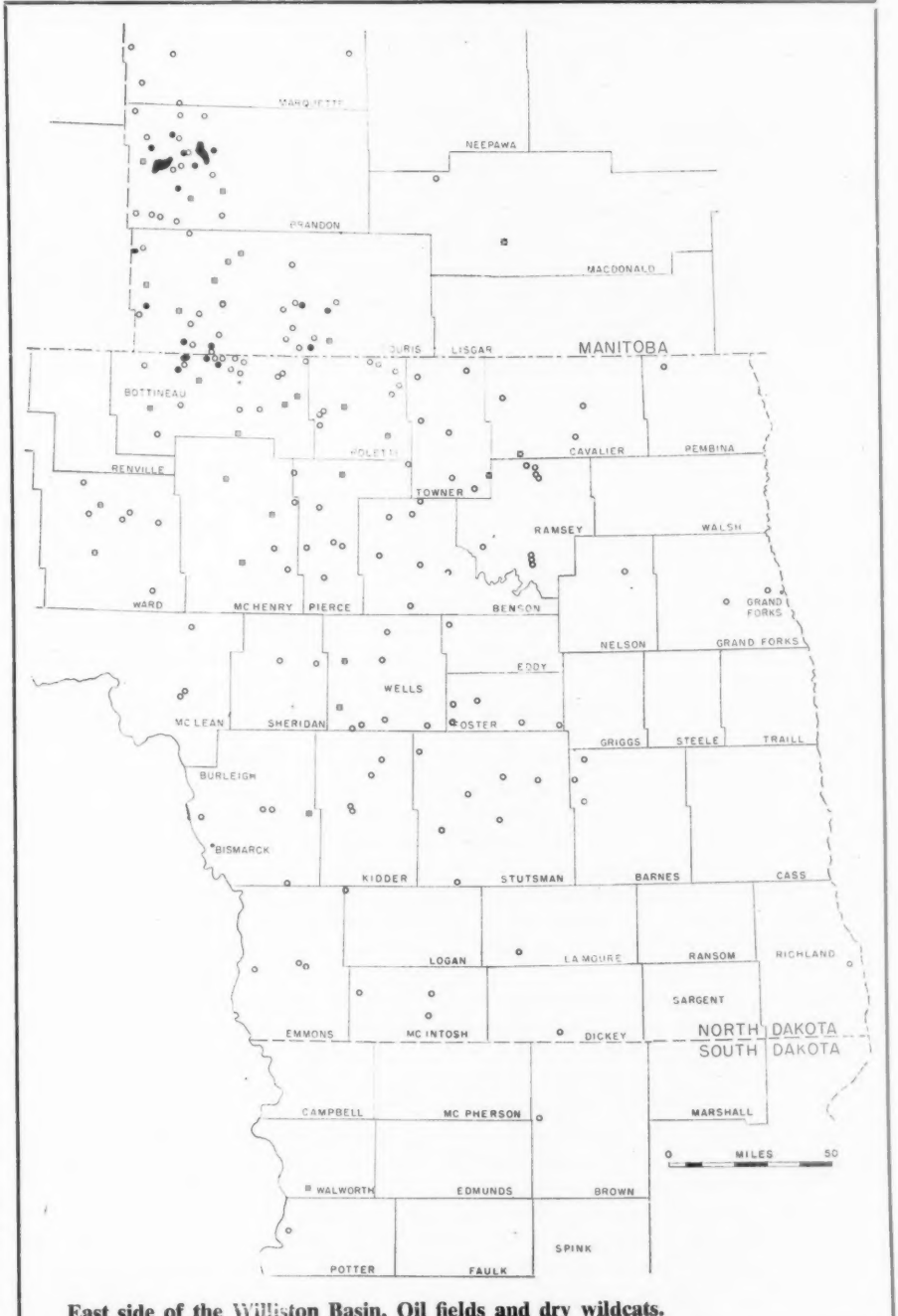
In addition to thickness and facies changes, non-deposition due to off-lap and over-lap history and subsequent erosion cause loss of beds that are present in the deeper parts of the basin. For these reasons, some lithologic correlations are poor, and much remains to be done to find out about the details of deposition.

Because of the production already established in Mississippian rocks, they are presently receiving the most attention. The Mississippian system contains, in descending order, the Amsden formation, the Big Snowy group, the Madison group, and the Englewood formation. In the same order, the Madison group consists of the Charles formation, the Mission Canyon, and the Lodgepole. All these Mississippian formations thin eastward by non-deposition normally, but in the middle of the area under discussion they disappear eastward one by one beneath Triassic and Jurassic beds as the result of erosion in post-Mississippian time.

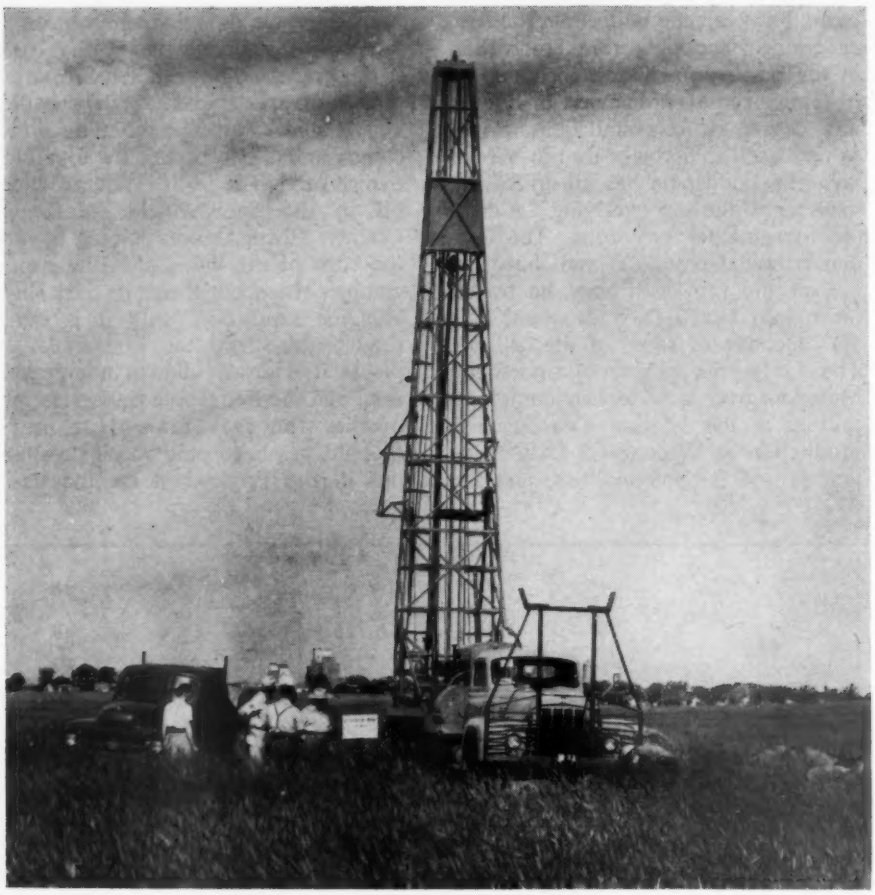
The present zero edge of the Charles formation is probably near the original limit of deposition. The Charles contains dolomites, limestones, anhydrite, and varying amounts of brown to red shale and siltstone. Oil has been produced from the Charles just below the unconformity in the Westhope field in Bottineau County. Some of the basal sandstones and silts there above the unconformity were also partly saturated but produced water. The Charles pay zone is a medium grained limestone that is partly or wholly dolomitized. It is similar in lithologic character to the underlying Mission Canyon. Charles is quite thin in the Bottineau producing areas, and oil is produced from similar Mission Canyon beds where Charles is absent up-dip.

The Lodgepole formation seems to transgress older beds toward the edges of the basin, so the older Lodgepole is not present in the wedge area. Lodgepole is generally darker colored and more shaly than the overlying Mission Canyon. On the edges of the basin, however, the Lodgepole is coarser grained and lighter in color than in the basin proper, and the increase in grain size plus a decrease in cement and degree of recrystallization serve to increase the porosity. In the Virden area the Lodgepole has an anhydritic member at the top overlying the crinoidal-fragmental pay zone. The Virden crinoidal pay zone and the chert bed at the top of it may be traced down into North Dakota, where it is the objective of some of the drilling. The Lodgepole crops out under the Mesozoic over a wide belt compared to that of the Mission Canyon. The production at Virden and Daly fields first proved its potentialities, and the very good wells at Roselea establish the Lodgepole as a first rate objective.

Below the Lodgepole in the basin is the Englewood or Bakken formation that is characterized by dark radioactive shales but also contains limestones and a sandstone, the Banff or Sanish sand. The Sanish sand produces oil in the Sanish field, McKenzie County, North Dakota. Going toward the edge of the basin, the Englewood changes character, losing its dark shale and the sandstone, until it is indistinguishable from the Lodgepole. In places it is absent due to non-deposition, and the Lodgepole transgressively overlies the Devonian. Not much thought has been paid to oil possibilities in the Englewood on the basin



East side of the Williston Basin. Oil fields and dry wildcats.



Nelson County, North Dakota. Zachmeier and Wetch Drilling rigging up in Joe Lamb's wheat field for an Oil Exploration Company 2400 ft granite test.

edge, but it may produce on the basin side of structures where it pinches out in an easterly direction as it does in the Virden region. Englewood may become more important as exploration continues.

The Devonian system varies in thickness from more than 1500 ft in Ward County to less than 300 ft in Benson and Burleigh counties, North Dakota. Most of the thinning is due to non-deposition. The exact pattern of Devonian sedimentation is still not known, but it is known that the occurrence of Middle and Upper Devonian rocks is not the same, and that the Upper Devonian probably extends farther and overlaps more extensively on the southeast part of the basin than was before supposed.

Devonian rocks lose their basinal characteristics on approaching the basin rim and become lighter colored, more sugary and less dense, and more dolomitic. The Elk Point salts are absent on the basin edge, and numerous red shale breaks attest to frequent non-deposition and unconformity. Where subsequent erosion hasn't destroyed oil originally present, production may be found in transition zone from basin to shelf type carbonates. Structure will probably be needed, and as yet it has not been found. The upper or Nisku beds of the Devonian have very good vugular porosity, and the granular Manitobian has good intergranular porosity. Cores of Devonian rocks from Cavalier County showed good secondary vugular porosity. Those wells were capable of flowing salt water, and if they contained oil would have been good producers. The vugular porosity in the Devonian occurs in traceable zones, but the nature of the porosity suggests that in detail it may be lenticular and that under proper conditions it might provide permeability traps. There is a local sandy development of the basal Devonian in Burleigh County that might have reservoir characteristics in its shoreline area.

The Sulurian system is similar to the Devonian in its regional changes. The Silurian is generally lighter colored than the Devonian. The edge facies of the Silurian do not have the upper organic zone that produces gas and distillate at Beaver Lodge. The rocks are alternating lithographic and granular limestones and dolomites with some coral development. Porosity is good in the granular and corralline parts, and the upper part of the Silurian section is vugular. No shows have been reported from Silurian on the basin edge. Thickness varies from 300 ft in Wells and Ramsey to 600 and 700 in McHenry and Ward counties.

The uppermost formation of the Ordovician is the Stony Mountain formation, an upper granular Gunton member with some sandstone similar to the Silurian and a lower shale member containing vari-colored shales and dense fossiliferous limestones. Stony Mountain is not usually considered to be an important productive possibility, but the Red River formation below it is.

The Red River formation is alternating dense and porous granular limestone and dolomite. It has produced oil on the Cedar Creek anticline in Montana and has had small shows of oil and gas in many places. Recently a shallow well in Dickey County, North Dakota, tested some gas in the Red River, and shows are reported from wells in LaMoure, Benson, and Ward counties. Where not eroded the Red River varies from about 600 to 750 ft, and it is more uniform in lithologic character than most of the units discussed here. It is the uniformity of the Red River that leads to the conclusion that it is potentially productive over most of the region. Red River has good possibilities on structure or where it pinches out below the Mesozoic.

The Winnipeg is a shale and sandstone formation that lies between the Red River and the Precambrian basement. A porous, quartzose basal sandstone is everywhere present in the Winnipeg, and in the southern part of the wedge-out belt there is a local development of an upper sand that may be a basal Red River unit. That sandstone thins and disappears both down-dip and up-dip. Both Winnipeg and Red River are transgressive in character, and in Grand Forks County, North Dakota, the Red River formation overlaps the zero edge of the Winnipeg and lies directly on granite. Normal thickness of the Winnipeg varies from 800 ft in Bottineau County to 350 in McHenry and 200 in Ramsey.

Post-Paleozoic Unconformity

The major factor that complicates east-side geology is the unconformity that records post-Paleozoic and pre-Mesozoic erosion. In the western part of the belt, Triassic red shales lie on Mississippian Amsden or Charles formations, and in Minnesota, southeastern North Dakota, and northeastern South Dakota, Cretaceous Dakota sandstones lie on Precambrian. There is a loss of section to the east in the Paleozoic due to unconformity and a similar loss in the Mesozoic due to non-deposition during eastward Mesozoic onlap. The accompanying paleogological map shows the distribution of Paleozoic formations below the

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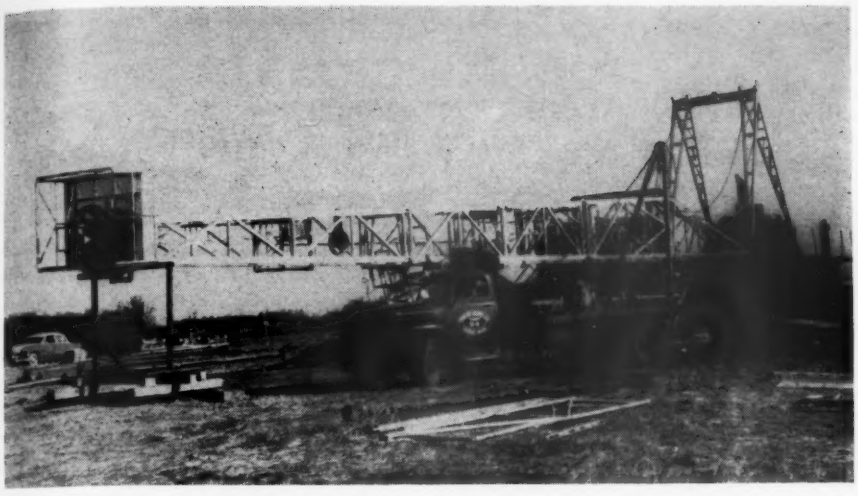


Hawke Drilling Company's National T-20 rig operating in Virden area.

Mesozoic. A narrow strip of Mission Canyon is bounded on the east by a wide belt of Lodgepole, and farther east are wide areas of Devonian and Silurian. In the south the Devonian and Silurian were probably never as extensive as in the north, and there a narrow belt of Devonian has Ordovician and Precambrian paleo-outcrops on the east.

Where any of the porous zones in the underlying Paleozoic formations rise to the unconformity surface, they form a potential oil trap in the wedge edge of the porous zone. A tight seal in the overlying Mesozoic is required, and local structure serves to localize the oil occurrence.

The topography on the unconformity surface is known to have high relief in places. In Manitoba one well drilled a normal section of Mississippian, and a nearby one went directly from an abnormally thick Jurassic sequence into Devonian. A well in Dickey County, North Dakota, went from Cretaceous Dakota into Ordovician Winnipeg three-quarters of a mile south of a well that had more than 100 ft of Ordovician Red River above the Winnipeg. The wells in Cavalier County established the presence of an irregular high area that contained a thicker Devonian section capped by an outlier of Mississippian Lodgepole limestone.

It can be predicted that further drilling will prove that the eroded Paleozoic surface is a westward dipping coastal plain with a karst topography. Scarps, sinks, valleys, gulches, and monadnock-like hills will be found, and there will also be large areas of nearly flat, gently sloping surface. The more resistant and thicker limestone formations will have eastward facing cliffs at their zero edges. These topographic features may prove oil traps where properly sealed, as those at Oklahoma City and on the central Kansas uplift do; others may be oxidized and eroded until all possibility of oil preservation is lost, as those drilled in Cavalier County, North Dakota, were. It is anticipated that the beds with more primary porosity will have lost any contained oil during the long period of erosion, but the more dense basinal beds may retain their oil to have it migrate into the volumes of secondary porosity formed as a result of the erosion.

The nature of the overlying Mesozoic beds is also of interest. Over most of the region the basal Triassic or Jurassic contains a thick impermeable red-bed section that would provide an effective seal. In the extreme east, a thick basal Cretaceous sandstone sequence is separated from the Paleozoic limestones by a thinner irregular red silt and shale that is only a few tens of feet thick. Where any amount of shale is present it should be an effective seal, but locally the shale may be absent, and oil or gas could escape to overlying permeable beds.

The topography and distribution of formations on the unconformity surface must be considered in evaluating the possibilties of the region, and a proper interpretation of the outcrop pattern there may lead to prediction of the structure of younger beds farther down dip. The map given here has large areas of apparently featureless geology that may not be real, but are probably due to lack of subsurface control. Such a lack is within the powers of the oil industry to remedy.

Prospects

The Williston Basin and east side development are still in their infancy, so any evaluation of future prospects must be based on long extrapolations of known conditions; and such extrapolations, however intelligent, will necessarily have to be modified, and we hope extended, as the region matures and our experience increases. As with a new product in any industry we must be optimistic in evaluating the good points of our invention and not be too discouraged by apparent difficulties. By analogy we may also anticipate that new and unsuspected uses and methods of manufacture will be developed as time goes on.

Working from the known to the unknown, present prospects seem best for development of additional production in Madison group limestones. Overzealous stratigraphers sometimes lose sight of the fact that, whereas a regional wedge belt of porosity serves to determine an oil province, most oil fields in wedge provinces are localized by some kind of structure. That has been the case on the east-side to date, and future successes will require a combination of proper porosity conditions and some structure. Present drilling in the Mississippian areas has outlined some structurally favorable areas, as has been pointed out, and tests planned will increase our information. Best production has been in Lodgepole to date, and the belt of pinch-out of the crinoidal zone is a first class possibility. Discovery of better porosity combined with structure in the Charles and Mission Canyon formations could also result in more discoveries.

Choice of second place objective is difficult, but the Red River formation is placed here because of present production in other places and because of the widespread small shows of oil and gas found in it. Wedge edges of porous zones, combined with favorable structure or surface topography could make an oil field.

Other possibilities are less promising at present, and their development is a long way off. Both Winnipeg sands, the upper one where it pinches out up dip, and the lower one where it is locally overlapped by Red River provide known favorable porosity conditions.

The Fryburg sand that produces oil in southwestern North Dakota and the Sanish sand both disappear up-dip in the wedge belt, one by erosion and the other by non-deposition. Porous Middle Jurassic Piper limestones are cut off by onlap, as are Middle Jurassic sands, but details remain obscure, and those beds must be classed as secondary or tertiary objectives at present. Cretaceous Dakota sands thicken and become more porous up-dip, but the Muddy sands above them are irregular and may provide traps somewhere in the wedge zone.

Remaining possibilities of unknown quality lie in conditions peculiar to the Paleozoic erosion surface and the transgressive basal Mesozoic. Combi-

nations of topography and porosity variation due either to secondary development of porosity or to onlap of basal sands may prove oil traps. Some Jurassic Ellis beds may be capable of generating oil for these traps, and many of the Paleozoic beds are capable.

Lastly, there is a distinct possibility of secondary accumulation in lenticular Mesozoic beds that lie above Paleozoic source and carrier rocks. This is a condition that is common in other regions and that was almost obtained in the basal sands in the Westhope field.

Conclusion

Fifteen years ago geologists thought there probably was oil in the Williston basin's edge, and a little over three years ago they were proved right. Serious exploration has been going on now for five years, and the subsurface geology of the area is beginning to be understood. Most of the drilling to date has been on very little geologic information, and most wells should be classed as stratigraphic tests. Increased knowledge of subsurface geology has been the result of the drilling, however, and a more orderly exploration program based on subsurface geology is expected in the future.

Drilling is probably the best exploratory method on the east side, and more use should be made of slim-hole and structure-drill equipment. Many geologists are working on the area; a study of stratigraphy and structure, supported by subsurface information in key areas, manufactured if necessary via slim-hole, should provide the key to the oil that should be there. * * *

NEW RIG DESIGNED FOR EXPLORATION

WM. T. RINTOUL

A NEW rig possessing several features unique to drilling rigs operating in the San Joaquin Valley, California, has been put into operation by the Rusty Walters Drilling Company, a Bakersfield, California, contractor. Design of the rig is such as to make it especially adaptable to a type of exploration that is becoming more and more widespread among California operators—the drilling of coreholes as a means of evaluating large lease blocks.

Typical of corehole drilling programs in California is that embarked on by Humble Oil and Refining Company late in April in northern California. As a means of evaluating upwards of 100,000 acres under lease in prospective gas lands between Lodi and Red Bluff, Humble moved in to drill the first in a series of 23 slim holes. Another pacesetter in the drilling of coreholes, is Shell Oil Company, holder of sizeable lease blocks in the Carrizo Plains and Merced areas of California. Shell reportedly has drilled more than 20 slim holes in the Merced area in central California.

Among the special features of the new rig are a telescoping mast, rotary table with splined bushing for four and one-half inch kelly, air tongs, special sub-base and drill tubing.

Rated capacity of the new rig with 4-in. OD 10-lb, 4140 seamless tubing with special Acme threads is 6000 ft. Tool joints (5¼-in. OD by 3½-in. ID by 7-in. long), heat treated, shrink fit onto the pipe. Drill tubing is cut into uniform lengths of 29.5 ft before makeup.

Racking capacity of the 100-ft guyless, telescoping-type mast with mechanical raising device is 7200 ft of 4½-in. drill pipe. Mast is mounted on a 2-axle, 8-wheel semi-trailer with air-operated remote controls from the driller's stand on the floor. Dimensions with the mast down are 51-ft 3-in. long, 13-ft 6-in. high, and 8 ft wide. Overall length of the tractor and semi is 60 ft.

In addition to the air tongs, which are used for the four-inch OD tubing, equipment includes two other sets of regular tongs for use with drill pipe and various casing sizes.

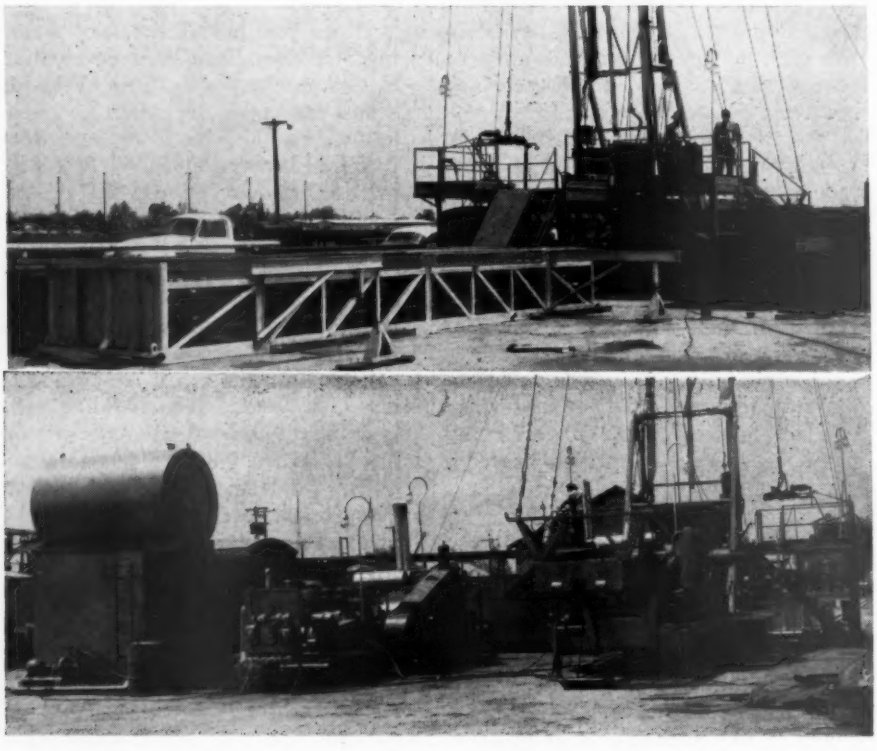
The sub-base has been built integral with the shaker tank and mud storage tank, which has a capacity of approximately 114 bbl of mud, complete with 3-hp mixing guns and mud-mixing platform. Dimensions of the sub-base are 7 ft 8 in. wide by 8 ft high by 40 ft long. A racking platform 7 ft wide slides into the sub-base during moves. Rotary table also moves with sub-base.

Other major components of the new rig include the drawworks with grooved drum and air starting, torque converter, spinning cathead, 4-cylinder, 200-hp diesel, 100-ton swivel, 4½-in. by 40-ft (37 ft working space) kelly, 7½-in. by 14-in. pump, powered by twin 340-hp diesels.

Pipe bins consist of two combination bins and racks with 8-ft outriggers on each side for casing racks. Capacity is 96 thirty-foot joints of 4-in. OD tubing.

Mud and water storage facilities are combined in one compartmented tank, with an additional tank mounted on top of the mud-water storage tank for fuel storage. Capacities for the various tanks are approximately 114 bbl for the steel mud storage tank, which is 8 ft by 8 ft by 10 ft; approximately 228 bbl for the water storage compartment, which is 8 ft by 8 ft by 20 ft, and 960 gal for the fuel storage tank mounted on top of the mud-water storage tank.

Rig may be moved in 7 loads. * *



Ground-level view of new rig especially designed for exploratory drilling.

Rear view of new rig. Note the compartmented storage tank at the left, with compartment for mud and water and a special tank mounted on top for fuel.

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IMPROVING ROTARY RIG OPERATIONS

Rig minutes are important — waste 5 of them a tour and you lose almost 4 rig days a year. Detailed studies of crew activities show much lost motion

WILSON J. BENTLEY*

JUST which *is* the most important part of the average drilling day? Is it the drilling time during which the driller is principally occupied with regulating the amount of weight on the bit? Or is the activity of making trips out-of and into the hole more important? These are questions that might easily be the subject matter for extended discussions, both academic and non-academic. From the standpoint of job design, or methods improvement in the oil industry, the question is: Is the time and effort of the crew members being used effectively? Looking at the situation from this viewpoint the two phases of the drilling day are equally important. Results are being obtained, time is being consumed, and money is being earned and expended. The answer to the question of human effectiveness then, is to study exactly what the crew does during its eight-hour tour and how the efforts of the individuals are expended and coordinated.

The very idea of "studying the crew's activities" might very well be considered an insult to the tool pusher or drilling superintendent. He might ask, "Who knows more about what my men do than I?" And the answer is obvious. He, along with the drillers, knows more than anyone about what the crews do. But he is one person, living in a possibly centralized location and driving between home and one, two, three, or four rigs. Much of his time is spent in driving, working on reports (which he dislikes), taking care of emergencies, or supervising completion of a well.

The present-day activities of this man allow him little time for close observation of the crew. The type of observation, that is, which will permit proper consideration and analysis. But the study and analysis of the job of tool pusher or drilling superintendent is a subject of discussion in itself. The objective of this article is to consider the activities of a crew-day and the method of study and possible results.

A previous article on the subject of job design described four important steps necessary to successful results in considering human work methods. The first step is to determine and record the current manner of performance. The second step consists of placing the information obtained in Step 1 in a form that will facilitate understanding and analysis. The third step is the analysis of the information that has been obtained and recorded. And the fourth step follows with the improved method resulting from this analysis.

These four steps sound quite simple and obvious. They, or variations of them, have been talked so much that the terms sound rather hackneyed. But this does not decrease their importance. Experience, so far, has continued to indicate that, for best results, an elemental break-down of the present method of operation is the safest ground work upon which to base recommendations for changes in the future.

Current studies of the activities of drilling crews during normal operations indicate that the efforts of many in-

ACTIVITY DATA SHEET

Operation: Drilling ahead on Well No 2 on Blank Lease Rig No 1

Sheet No. 1 of 9 Sheets

Date: March 3, 1954

Operator: Jones (Roughneck) Observer: Bentley

Time Reading P.M.	Subtracted Time	Description of Activity
3:20		
3:30	10.0	Change Clothes
3:34	4.0	Talk with Smith in doghouse (Smith-Daylight Crew)
3:37	3.0	Check shale shaker
3:48	11.0	Stand with Driller (while drilling ahead)
4:02	4.0	Check water level in tank
4:10	8.0	Put canvas cover on mud sacks
4:19	9.0	Check engine of electric light generator and service
4:33	14.0	In doghouse looking at bulletin board and mail from management

FIG. 1. Activity data sheet.

*Associate Professor, Oklahoma Institute of Technology, Oklahoma A. & M. College.

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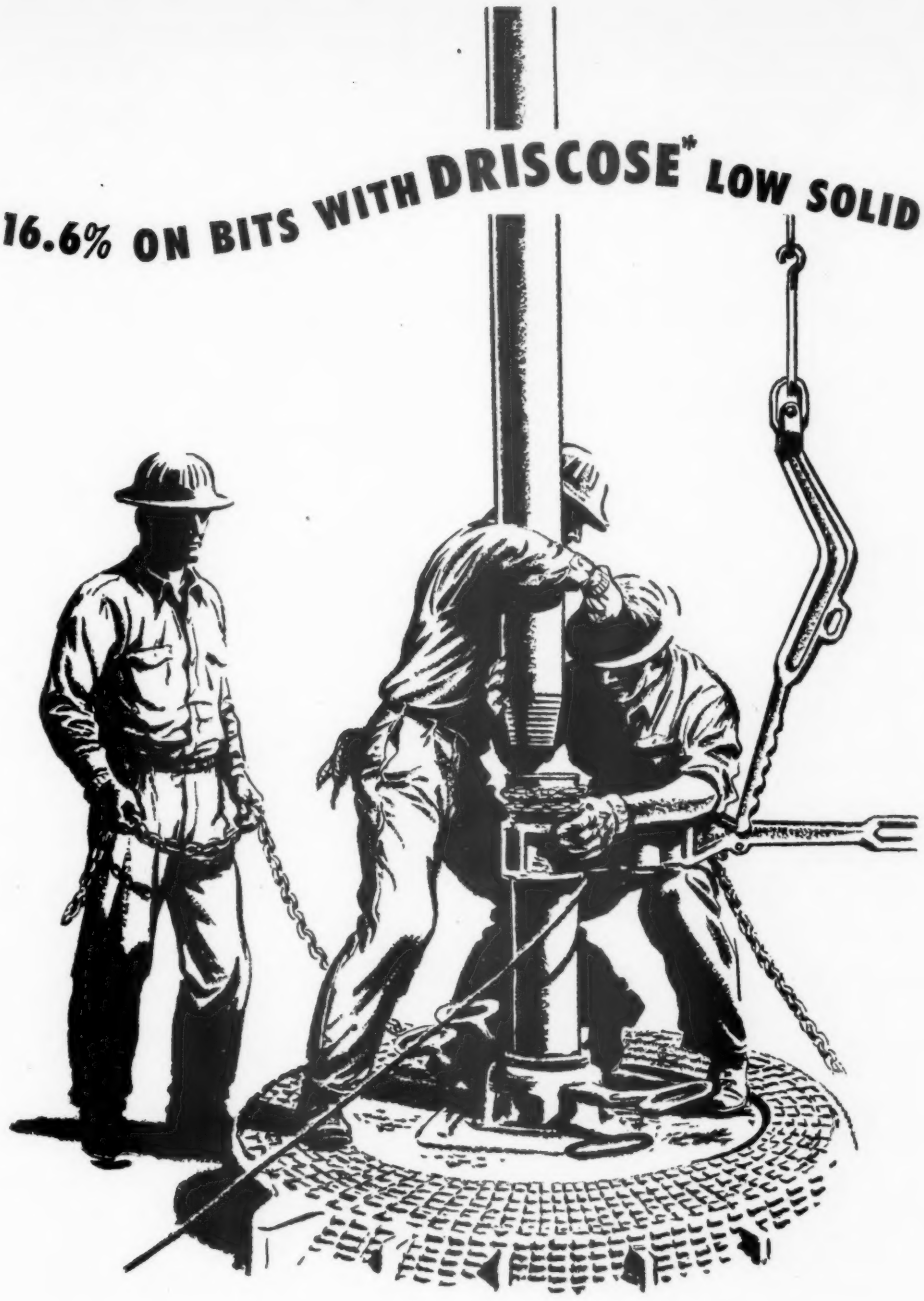

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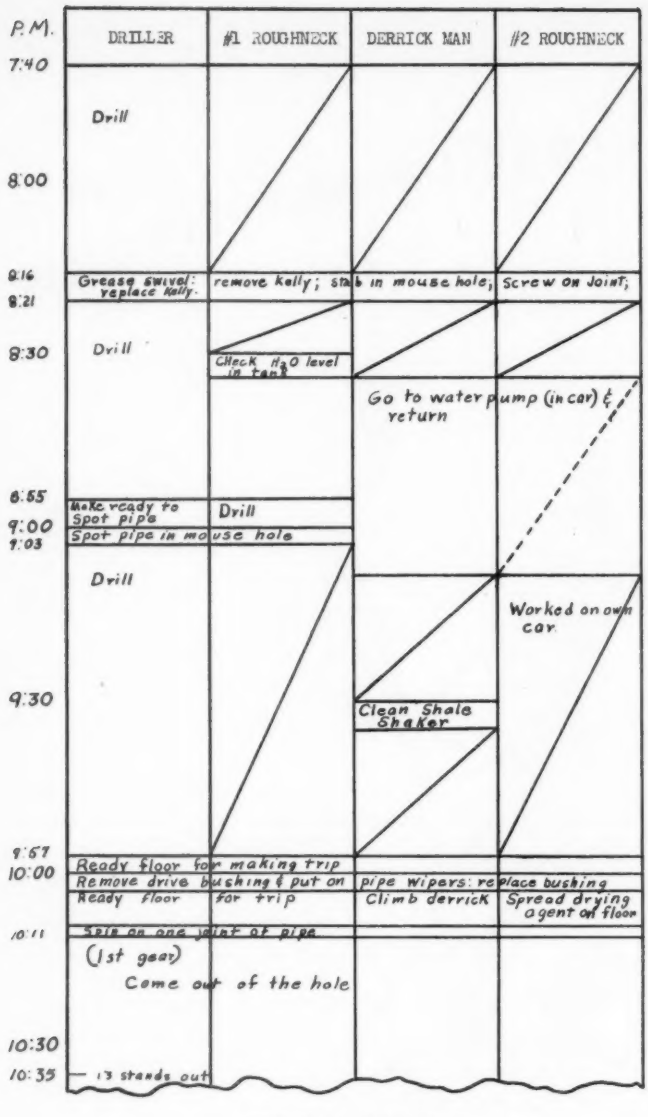

FIG. 2. Activity chart.

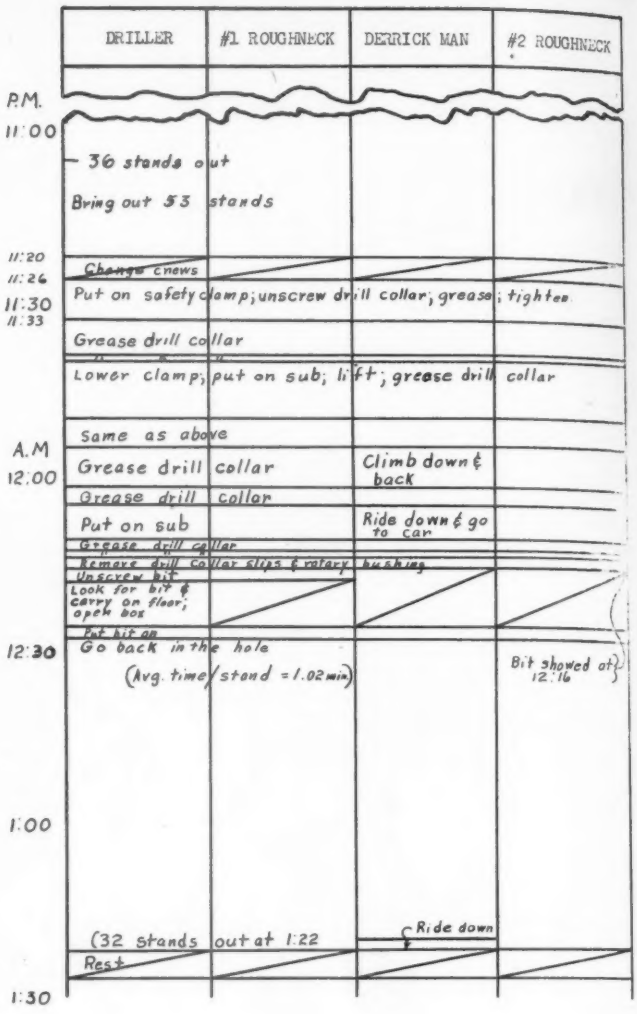

FIG. 3. Activity chart.

dividuals are not being used most effectively. Normally this condition does *not* reflect a desire (on the part of any individual) to waste time, but does indicate a lack of motivation and a deficiency in knowledge of how to plan ahead. The planning driller or toolpusher, after giving his directions for normal operations, says, "As soon as you get loose from this, work on that; when you get through with that, work on this; and when you aren't doing anything else, clean up tools and straighten up the doghouse." He is not necessarily a slave driver at all, but is only outlining a normal work load for the time that the men are getting paid.

Traditional assignment of duties to the evening tour crew, the morning tour crew, and the daylight tour crew are not necessarily inefficient. But they should be examined and evaluated with an open mind from the viewpoint of: (1) operationally speaking, *when* is the best time to do them? (2) from a crew size standpoint, during which tour should the duties take place? (3) from a crew (or individual) standpoint who is best qualified to do the duties? (4) from a human relations standpoint who should do them and when? Always, for improvement, we need this probing and questioning analysis with a human understanding overtone.

To really *know* how the efforts of the crew members are being utilized requires the sequential recording of the elements of work performed. At the same time, to know the comparative length of time consumed by the various elements, clocking or timing is necessary. The use of a stop watch in timing job elements of two or three minutes, or more, is not necessary. When elements are shorter than two or three minutes and recur often a stop watch is considered desirable. The stop watch usually used has a minute sweep-hand with the face calibrated in decimal minutes. (This makes it unnecessary to convert from seconds to minutes.) It also has a cumulative dial and hand that will read up to thirty minutes.

When it is decided that a study of the activities is going to be made all personnel involved should be told about it. Under no circumstances should an "undercover" study be made. Top management never likes to be tricked. Likewise, one cannot expect operating groups to cooperate if they have reason to believe that they are being spied upon. Their help in analyzing results is needed and should be solicited. Honesty and ethical tactics should be scrupulously practiced by those authorizing such a study and by those obtaining data. A detailed explanation of the techniques used is not usually necessary or expected by field personnel. An explanation of the objectives of the study, a request that the crew go about their usual duties in the normal manner, and an assurance that they will have the opportunity to see and discuss the results is usually sufficient.

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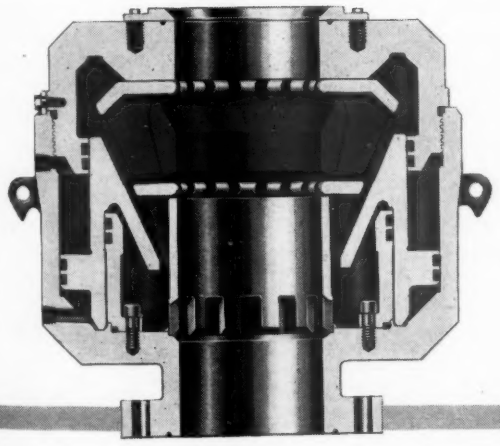

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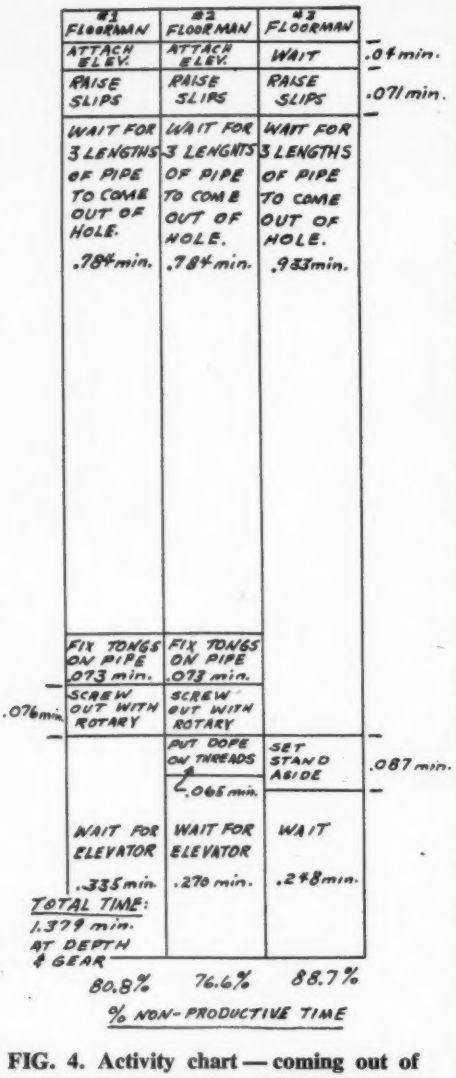

FIG. 4. Activity chart — coming out of the hole. Cycle time for raising and setting aside one triple stand.

the author likes to conduct the actual study (after all the preliminary explanations have taken place).

A good time to start observing and taking time data is just as a crew goes on tour. A data sheet is designated for each crew member. Record the time for starting the observations in the column marked "Clock Reading" (see Fig. 1). Then each activity of each man on the crew is described in brief meaningful phrases. The time of completion of a particular activity is recorded opposite the description. This method of describing the work being performed concurrently by each crew member and recording the time of completion (of each activity) is continued for the desired period.

After the data taking is completed the time for each element of work can be obtained by finding the time difference and filling in the "Subtracted Time" column (as shown in Fig. 1). These elemental time values can then be transferred to a sheet of graph paper to make an activity chart similar to Fig. 2. Here is shown, very clearly, the activity of each man in relation to every other member of the crew. With this graphical picturization of the crews activities an accurate idea of the utilization of their individual and co-operative efforts is obtained.

To list a series of rules resulting from such a study as has been described would not be of particular value. Rules of good supervision can be found in practically every publication on the subject. Company practices and individual desires and qualifications often affect the procedures recommended as a result of this type of study.

Fig. 2 represents a work segment taken from a normal evening tour. It will be noticed that the time shown is from 7:40 p.m. to 10:35 p.m. The spaces that have diagonal lines drawn across them are time periods when the crew members had nothing to do. Dotted diagonal lines indicate a time period during which the crew member was helping in some manner, but was not actually needed in the operation. For example, 34 minutes were consumed by two men driving less than two miles to check the water pump, cut it off, and return. Only one man was needed for this job. It might be argued that the second man was not needed at the rig so he might as well ride to the pump. Analysis of this situation, of course, indicates that there is more liklihood of the second man being needed at the rig than at the pump. So he should have stayed at the rig even though the driller had no immediate need for him. Additional reasoning for this policy is the fact that, as soon as the men leave the rig, the driller's supervisory control is greatly decreased.

Upon further examination of the activity chart (Fig. 2) one can observe the relative amount of time spent by the No. 2 roughneck working on his own car, 49 min. From this observation evolves the principle question of whether there was any maintenance or clean-up work that could have been done during this period.

A wealth of information can be gleaned from this type of chart. For instance it took:

1. *Five minutes to grease the swivel, remove the kelly, stab in mouse hole, screw on joint, and replace the kelly. (4 men).*
2. *Five minutes to roll a length of pipe in place to spot in the mouse hole. (1 man).*
3. *Three minutes to spot a length of pipe in the mouse hole. (2 men).*
4. *Three minutes to remove the drive bushing, put on pipe wipers, and replace bushing. (4 men).*
5. *Three minutes to straigntен up the rig floor and get ready to make a trip. (4 men).*

A summary of the 2 hours 55 min charted indicates that the driller was *productively* occupied 100 per cent of the time; the No. I roughneck, 38 per cent; the derrick man, 47 per cent; and the No. 2 roughneck, 25 per cent. This information reveals excellent possibilities for planned activities of maintenance around the rig. Then, should all maintenance and clean-up be completed, training is always an excellent activity with which to fill up the non-productive spaces on the chart. The important thing, though, is to have a method of observing and recording the activities. Good common horse-sense and advance planning can then be more easily implemented.

Making a trip in and out of the hole is another area of activity that should be examined. The technical aspect of when the driller should start out of the hole is not to be considered here, but rather the methods employed and the utilization of the men. In most cases there is good understanding between the toolpusher and the driller as to the conditions under which the driller decides to bring the string out of the hole and change bits. One would normally think that these conditions could happen most any time during the eight-hour tour. It is amazing how often the decision to change bits is made when there is only time for the crew to make *half* the trip. There is a strong possibility that if the toolpusher were around the rig 30 minutes to an hour previous to the estimated time of making a trip he could help the driller in making his decisions as to whether to start now or later.

An activity chart picturing the activities of the crew during a round trip is shown in Fig. 3. This is a continuation of the chart started in Fig. 2. The time period from 11:00 p.m. to 1:30 a.m. has been charted. The same type of open-minded questioning attitude and analysis should be applied to the activities represented by this chart. Listed below are some of the items to note:

1. The rig was inoperative for four minutes while the evening tour crew went off and the morning crew came on.
2. The time it took to put on the safety clamp, unscrew the drill collar, grease, and tighten varied from 7 min to 2 min.
3. To put on a sub took 6 min.
4. The derrick man made three trips to the ground and back during a 1½-hr period. (for no apparent reason)

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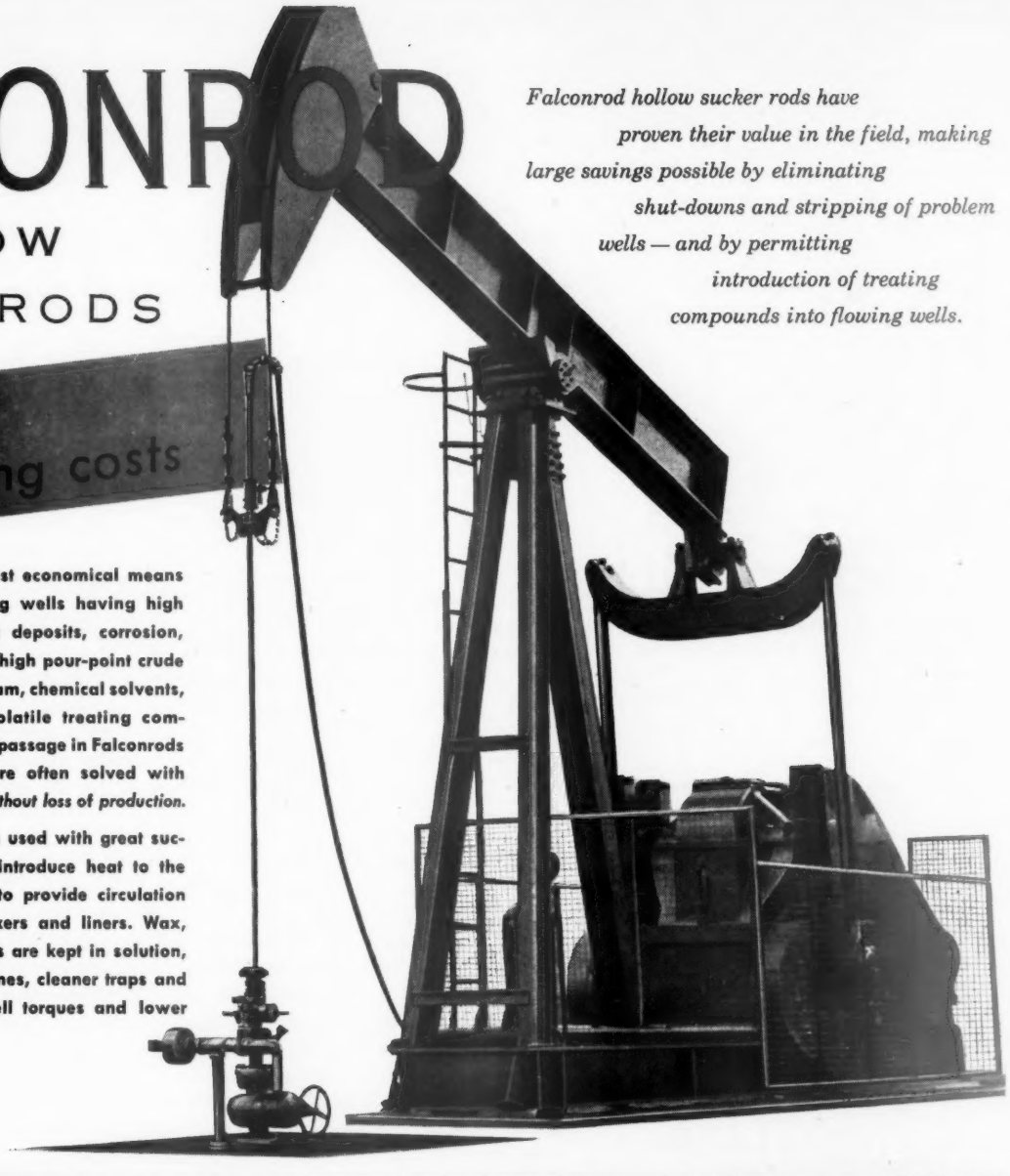

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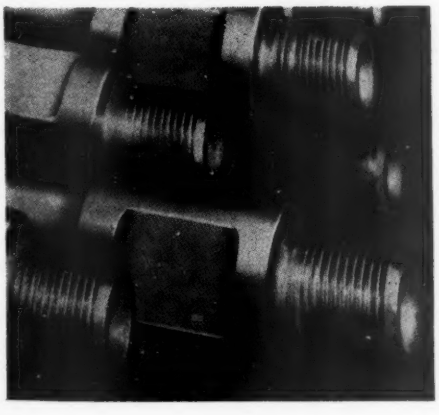

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5. To grease a drill collar took from 1 to 2 min.
6. To unscrew a bit took 2 min.
7. To find the right new bit took 8 min.
8. To screw a bit on took 2 min.

Let us consider the first item for a moment. Off-hand, 4 min of non-operating time while the crews change does not seem significant, but *minutes are important*. This 4-min period amounts to 12 min per day or 3600 min out of a 300 day year. This 3600 min is equivalent to 2.5 days per year.

The same activity can be considered from a man-hour expenditure viewpoint. Each four minute period consumes 16 man-minutes of non-productive time or 48 man-minutes per day. Figured on a 300-day year this will amount to 30 man-days saving. What drilling company wouldn't like to make 30 man-days by saving 4 min.

Consider the second item now. There was a big variation in time required to move the safety clamp, unscrew, etc. What is the reason for this? What are the elements that make the variation? Are there some conditions that can be altered that will result in a shorter, stabler operation? The specific situation will dictate the answer.

It was noted (Item No. 4) that the derrick man came down to the rig floor. What were the reasons for doing this? In this case the reasons were purely social. This item is a time consumer and often disrupts the co-operative efforts of the entire crew.

Item No. 7 is an important one — the time out of the hole during a trip. Observation of 60 trips showed that the time out of the hole varied from 5 min to 35 min. The reasons for excessive time were quite varied. One of the principle time takers was the practice of *not* having the new bit on the rig floor by the time the old bit showed. Obtaining the new bit often took as much as 10 to 12 min. The same type of time-money calculations can be made with this time element as with that describing the crew-changing element (Item No. 1 above). A significant saving of 25 operating hours per year (based on an average of one trip per 24 hours of rig time — and a 300 day year) can be obtained by just reducing this time period by 5 min per trip. Much can be accomplished by having a standard procedure for each member of the crew to follow and training them in this procedure. In addition, it is a well known fact (but not so well followed) that it is economically sound to clean all equipment and tools and put them in their proper places immediately after the finish of trip operations.

One additional look at this general area of activity should be taken. Fig 4 is an activity chart showing the co-operative efforts of the crew during the removal of *one* triple length of pipe. In essence this is putting the magnifying glass on a 1.379 min time-period in Fig. 3. Activities of the driller and derrick man are not pictured as their work and location remove them from consideration. This is a five-man crew with three men working on the rig floor in addition to the driller. The time values represent averages of about 20 observations.

The most obvious fact that appears here is the predominance of non-productive time. The No. 1 floorman was idle 80.8 per cent of the time cycle, the No. 2 floorman 76.6 per cent, and the No. 3 floorman 88.7 per cent. This is the one time around the rig when the most men are needed, and yet, when analyzed it is found that they are less than 20 per cent utilized! Are three men on the floor really necessary? If so, *why*? In this particular instance the one activity that required three men was that of raising the slips. If this operation or equipment could be altered so that only two were necessary, the balance of the work elements could be accomplished without extending the total time or over-working the men. Further study and analysis of this chart may easily point up other possibilities of changes.

It must always be remembered that illustrations and time figures are taken from specific situations and that enough observations must be made to establish beyond doubt that the real picture has been obtained. The type and condition of rig, the power available, the size, weight, and length of the pipe string, and the number of lines on the traveling block are just some of the mechanical features that may vary the situation. The weather conditions, age and physical conditions of the workers, the experience of the workers, worker morale, and company attitude are more items that will undoubtedly effect the time and methods. It must be understood that the knowledge of what the methods are and how the men are utilized puts those who manage and supervise in a position from which decisions can be made. The decision may be to make no changes. But, at least, this decision is made with full knowledge of the facts. The general method of investigation and analysis remains the same. A clear and accurate picture of the present method of operation *can* be obtained by these methods. This picture, submitted to an unbiased questioning of each element, forms the basis for the pooling of ideas by operating personnel. Management can then be most certain of a resulting practical solution to methods problems.

* * *

First of a Series

Lateral Drain Hole Drilling

How important is this method of increasing well production? — A discussion of equipment development and the results

H. JOHN EASTMAN

The question, "How important is lateral drain hole drilling?" has been asked by oil men throughout the world. They also are interested in how successful it has been. To say that it is always the answer to increased production would be a fallacy. It has, however, in many instances been a method of getting oil from dry or nearly dry wells. It has also increased production. Lateral drain holes can be drilled out 30 to 100 ft from the main bore into the hitherto untapped oil sands, so that they may drain and channel the oil back into the bore.

Until recently, imperfections in the design of the necessary drilling tools, and the failure of anyone to assemble all the case histories of experiments with drain holes led to considerable skepticism in the oil industry about their value.

This first in a series of articles has for the first time assembled all the known data on the drilling of lateral drain holes.

The Author

H. John Eastman is founder and president of the Eastman Oil Well Survey Company, a specialized service company for directional drilling and oil well surveying in the oil industry. He has written many articles on directional drilling and oil well surveying and is considered an authority in the industry. Eastman's early days in the oil industry were spent as production superintendent for Magnolia Petroleum Company in Oklahoma. Later he was a salesman for Standard Oil of California. The company bearing his name was founded in 1930 in Long Beach, California. Today it is known throughout the industry as the pioneer in its field. The firm operates 26 offices in the United States, 5 in Canada, and 1 in Germany.

DEVELOPMENT of equipment and techniques for studying producing reservoirs show much more oil is left in the productive sand than is extracted by ordinary methods of recovery. Since many of the stripper fields were drilled when recovery methods were not as well perfected, new techniques are being tried experimentally to increase ultimate recovery. Undoubtedly many wasteful methods were used in primary recovery before production methods had advanced to the present state and development has not yet reached its peak. Probably we will look back to this time as one of inefficiency due mainly to lack of knowledge and tools to perfect better methods.

Lifting costs give impetus to the investigation of means for producing more of the oil contained in the reservoirs. As wells become older, the production rate declines and the unit cost of recovering each barrel becomes greater. Production equipment fails more frequently and, inflation has increased the cost of all remedial work without a proportional increase in the price of oil. Large quantities of water, lifted with the oil in older wells, are expensive to handle and contribute nothing to the operators income.

Much research and experimental work is being done at the present time to evolve new methods of secondary or even tertiary recovery. Gas repressuring and water flooding have been in successful use for years, recovering in many cases more oil than was drained from the reservoir originally. Accounts have appeared on experiments on burning a portion of the oil in place at the bottom of the well. By controlling this combustion process, the application of heat to the reservoir increases oil mobility by decreasing the viscosity of low gravity oils. Hydraulic fracturing has proved a great stimulant to further production in wells bottomed in certain types of reservoirs. Most of these new methods of recovering a greater percentage of the oil in place are confined in their applications. In most cases the payout of these systems is over the years and not in a few months of increased production. Few wells can be expected to attain the flush production they yielded originally.

EXCLUSIVE

One production aid to depleted wells has consisted of drilling short lateral holes within the oil sand out from the main bore. Lateral drain hole drilling is not to be confused with directional drilling which consists of deflecting the main bore of the well to bottom at a predetermined point generally at some distance from the surface location.

It has been deplored by many engineers that thousands of feet of hole is dug, cased, and maintained for years in order to produce from a relatively few feet of oil sand exposed at the bottom of the well. If this vital surface of contact with the pay formation could be increased, it was reasoned that the well should be more productive. Many attempts have been made to do this over the years.

Mining for petroleum, especially where gas depleted pay sands existed at shallow depths, has been practiced for centuries in some parts of the world. One of the first instances of oil mining in the United States occurred in 1865, when the New York Enterprise and Mining Company sunk a 165-ft shaft to an oil sand in Warren County, Pennsylvania.

Oil mining in Germany is being used as a successful secondary recovery method in several shallow fields, At Wietze, oil mines have yielded 5,000,000 bbl of oil in the last 32 years, more than the 480 wells drilled into the same sand produced in 80 years. The reservoir is made up of loose, dry oil sands, sandstones and limey sandstones from 210 to 240 ft thick. It is estimated that mining will yield 26.5 per cent of the oil content of the sand ultimately. Present production of the Wietze mine is about 400 bbl per day.

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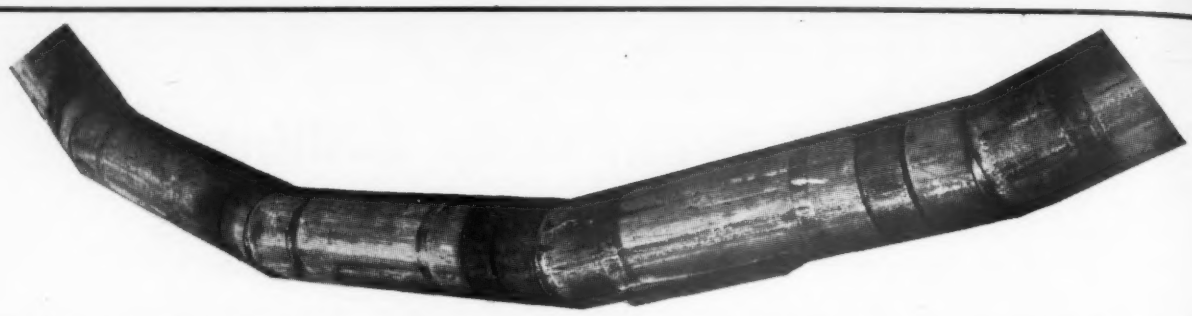

Segments of Lee's angular drilling tool assembled and bent to maximum curvature. Lug on side engaged groove in deflector to preserve initial orientation.

At Pechelbronn the oil bearing sands and sandstones occur in lenses from 7 to 10 ft in thickness. About 6,250,000 bbl of oil have been recovered by mining processes in this field. Daily oil production of the Pechelbronn mine is 530 bbl of oil at present.

Mining is classified as direct or indirect. In the former system tunnels are driven into the reservoir itself to make the rock yield by free seepage. The indirect method of mining consists of driving tunnels in the beds overlying or underlying the reservoir itself. From there the reservoir is tapped by underground shafts or subsurface wells.

Oil mining ventures indicate that a greater exposure of productive sand in any well is desirable and that much oil otherwise unrecoverable is produced.

A review of old patents concerned with the idea of exposing more oil sand in a well is revealing. A United States patent was granted to J. L. Addison in 1891 on a "Groove Cutting Machine for Oil or Gas Wells." The object of this intervention was to "renew or increase the flow by opening fresh fissures, channels or cavities."

Bernard Granville of New York applied for patent coverage on a drilling apparatus in 1919 for drilling horizontal holes extending out from a main bore. Granville hoped to reach sources of oil and gas "within a radius of several hundred feet" by drilling laterals with his apparatus.

In 1929 and 1930 Granville received patent protection on two types of heavy duty flexible drive shafts which obviously were invented to drill lateral drain holes when used with the casing and elbow assembly.

Between 1922 and 1931 four other patents were granted on apparatus designed to drill lateral holes. All of these seem to be somewhat impractical in the mechanisms used for drilling. Probably they all failed because the equipment was not designed with sufficient strength to drill laterals successfully.

Prior to 1929 a number of experiments were made on the movement of oil through media by the Bureau of Mines. Models of different types of reservoirs were constructed and the oil was extracted from them by conventional methods. These studies were made at Bartlesville, Oklahoma, and Oil City, Pennsylvania, where they could be observed by reservoir engineers.

One of the observers of these tests was Robert E. Lee of Coleman, Texas, who left the experiments convinced that ultimate production could be increased by forming channels in the oil sand itself. He had seen the effect of explosives and reasoned that some practical mechanical device could be invented that would bore auxiliary channels out from the well bottom. Lee's original idea was to use an air actuated bit of the percussion type for cutting lateral holes. This apparatus was designed and operated experimentally and an application for a patent was filed in 1930. Trials proved, however, that a rotary bit would give much better results, so Lee redesigned and constructed improved equipment.

This rotary mechanism was constructed and used to drill lateral holes in a number of wells in Texas fields. The assembly consisted of four main parts — a deflector section for forcing the bit to drill in a certain desired direction, an air driven bit and reamer for drilling the lateral, a set of drilling segments directly above the bit which flexed in one direction only and locked at the limit of bend, and a similar set of non-locking segments run above the locking sections and connecting with the conventional drill stem.

This equipment was successfully used to drill the first truly lateral holes in 1929 at Texon, Texas, for the Big Lake Oil Company. Two 5¼-in lateral holes were drilled out 23 to 24 ft horizontally from the original well bottom in the St. Andrews lime at depth of about 3000 ft. Before the laterals were drilled the well was producing about one and one-half barrels of oil per day from the depleted lime reservoir. For the next 10 days after the drain holes were drilled, the well produced at the rate of 60 bbl of oil per day. Subsequent production figures are not available but the well was abandoned 4 years later.

Lee, wishing to verify that the laterals were actually drilling to horizontal or above, made the first survey of a drain hole in 1931. He used a set of acid bottles in short segmented barrels and, from these drift records, established that the bit was forced to drill horizontally on a very short radius. In fact, one hole 70 ft in length turned upward to form a "U".

Some time in 1939 Lee started to redesign his angular drilling tool to overcome the disadvantages proved by experience in drilling with an air motor. The subsurface air exhaust had proved impractical and no simple solution for surfacing the air had been found. The removal of cuttings was complicated by fluid, also the use of air and large compressors was costly and dangerous. The main new feature of the tool was that the bit was driven by rotating the drill pipe at the surface in the usual manner of conventional drilling. Drilling fluid served to lubricate and cool the bearings on the drive shaft and universal joints, as well as to remove the cuttings from the lateral hole. As the bit was free to move longitudinally in its bearing, it was forced ahead by the pressure of the circulating fluid also.

This improved angular drilling equipment was first tested on the Stone-Willis well in Brown County, Texas. This well was producing 60 bbl of salt water, having been drilled 10 years previously. It was used as a test only, since there was no possibility of getting further oil production. Three 25-ft lateral holes were drilled at a depth of 2600 ft. Water was employed as a circulating fluid with drilling done with 500 psi pump pressure. The 5¼-in. bit was run with a weight of 400 lb per in. of diameter or about one ton total weight. Production of salt water was increased from 60 bbl per day to 400 bbl per day after the lateral holes had been completed. The new type drilling equipment operated much better than when the air motor had been used. Some trouble was experienced with the

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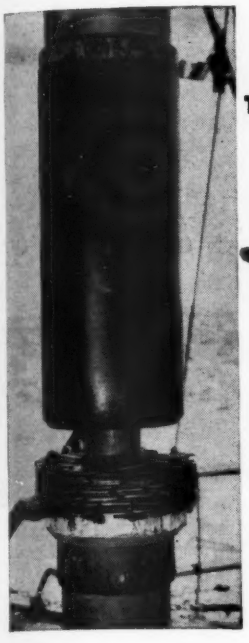

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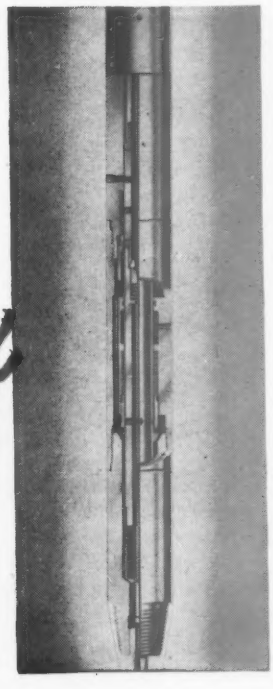

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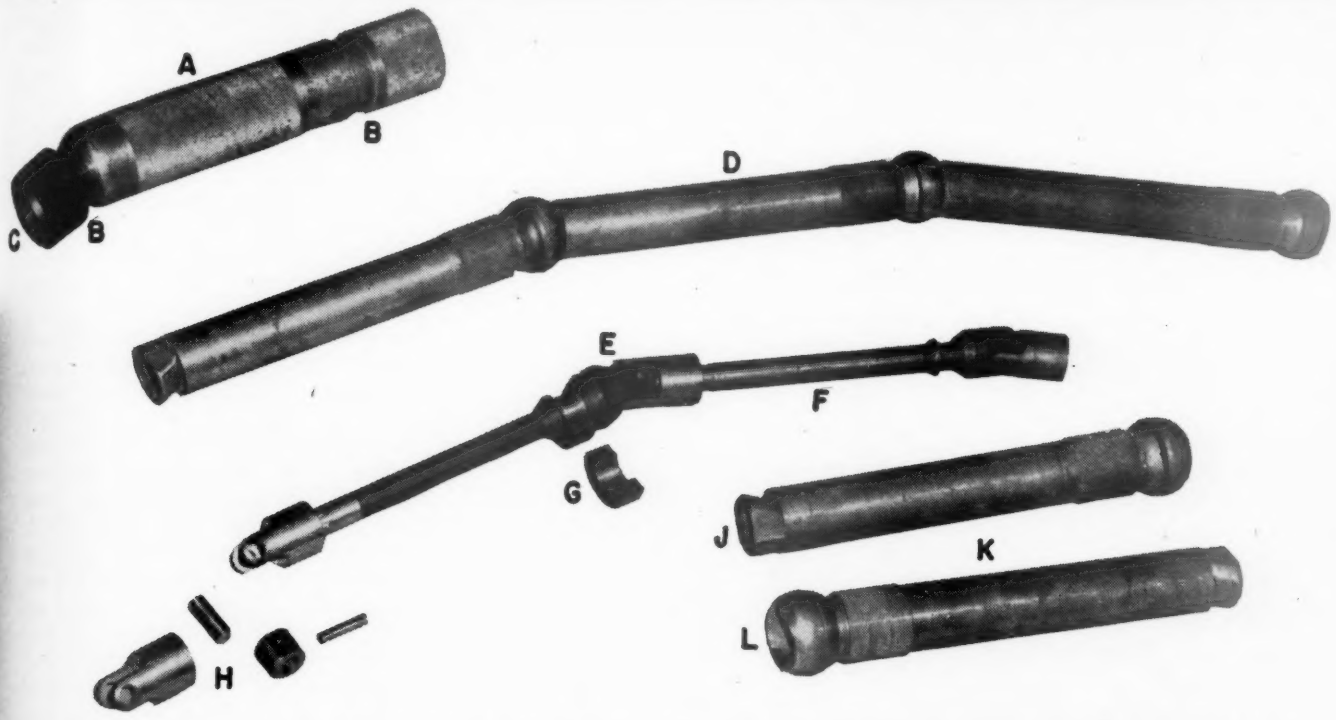

Parts of drilling section of Lee's second angular tool. Flexible segments are same as the first tool design. A. Bottom flexible section assembled. B. Flexible joints. C. Thread for drilling bits. D. Inner sections of flexible segments assembled to show amount of bend. E. Universal joint. F. Splined drive shaft. G. Split bearing for drive shaft. H. Universal joint assembly. J. Socket flattened to fit recess in ball at an angle to limit amount of bend. K. Hollow inner flexible segments. L. Ball with recess for socket. Two sides are flat and parallel.

sand in the circulating water cutting the bearings in which the segmented drive shaft ran. The tool worked very satisfactorily, however, and in this test increased the flow of salt water almost 7 times by drilling only 3 short laterals.

A depleted well in Coleman County, Texas, which made 20 bbl of oil per day was drilled with 2 laterals in the lime reservoir, one 3 ft and the other 16 ft in length. Water was used as a circulating medium for drilling the laterals. No increase in production occurred.

It was considered that the use of water prevented maximum benefits from the drilling of drain holes. The decision was made that in all future angular drilling, oil would be circulated to prevent contamination of the reservoirs. Oil also would serve as a lubricant for the moving parts of the drilling tool.

In 1935 and 1936 a number of wells were worked over with the angular drilling equipment in Shackelford County, Texas, using 30-deg gravity oil for a circulating medium. Most of the wells chosen for this type of workover were strippers yielding from 5 to 6 bbl of oil per day. Four old wells were reworked by drilling from 4 to 6 drain holes in the producing zone of each well. Short laterals that extended from 12 to 15 ft horizontally from the main bore were drilled in different directions like the spokes of a wheel. Production was increased from 5 bbl of oil to 20 bbl on the average.

Lee presented a novel method of repressuring and flowing wells by utilizing two sets of lateral drain holes spaced one above the other and the patent on this method was granted in 1931. He proposed to drill a number of laterals on two separate levels in the oil reservoir. A perforated liner would be run to a point opposite the lower set of drain holes with a packer set below the upper set of laterals. A repressuring medium would be pumped down the annulus between the casing and the liner and out into the upper horizontal holes in the sand to force the oil downward to the lower set of drain holes which would be produced. He also suggests that the repressuring gas to be superheated to reduce the viscosity of the oil and to dissolve viscous matter such as paraffin and asphaltum. None of the many angular holes he drilled were ever lined, however, nor was this novel method of repressuring used.

In 1941 Leo Ranney described a method for drilling horizontal holes within the oil sand for additional recovery from a depleted sandstone near McConnelsville, Ohio. A shaft was sunk to the depth of the oil sand and a drilling chamber of sufficient size to accommodate the drilling equipment and crews excavated. Six horizontal holes were drilled from this chamber out into the oil zone. The 3-in. diameter laterals were drilled in opposite pairs. A red pulling machine pulled the drill rods from one hole and ran them into a hole being drilled in the exact opposite direction. Thus drilling time was reduced since it was unnecessary to disconnect the rods. This drill pipe was run in and out at the rate of 100 ft per minute wherever it was necessary to change bits. With a crew of 2 men on the drilling machine, an average of 55 ft of hole was dug in a 7-hour shift. The holes were surveyed with acid bottles every 50 ft to be sure that they had not varied from the predetermined course. Over a mile and a half of laterals were dug in this way at an estimated drilling cost of 90 cents per foot. One hundred feet of light casing was grouted into the mouth of each horizontal hole after which each lateral was shot with nitroglycerin to break up the formation.

Ranney claimed that the shooting of these bores was more successful than shooting of vertical wells as the formation was broken parallel to the bedding plane of the sand. Since in one instance it was found that the 250 ft of earth over the hole had lifted 1½-in. it was concluded the explosive shock had shattered the beds vertically as well as horizontally. The first horizontal hole flowed by gravity, producing 5 bbl of oil per day in spite of a saturation of

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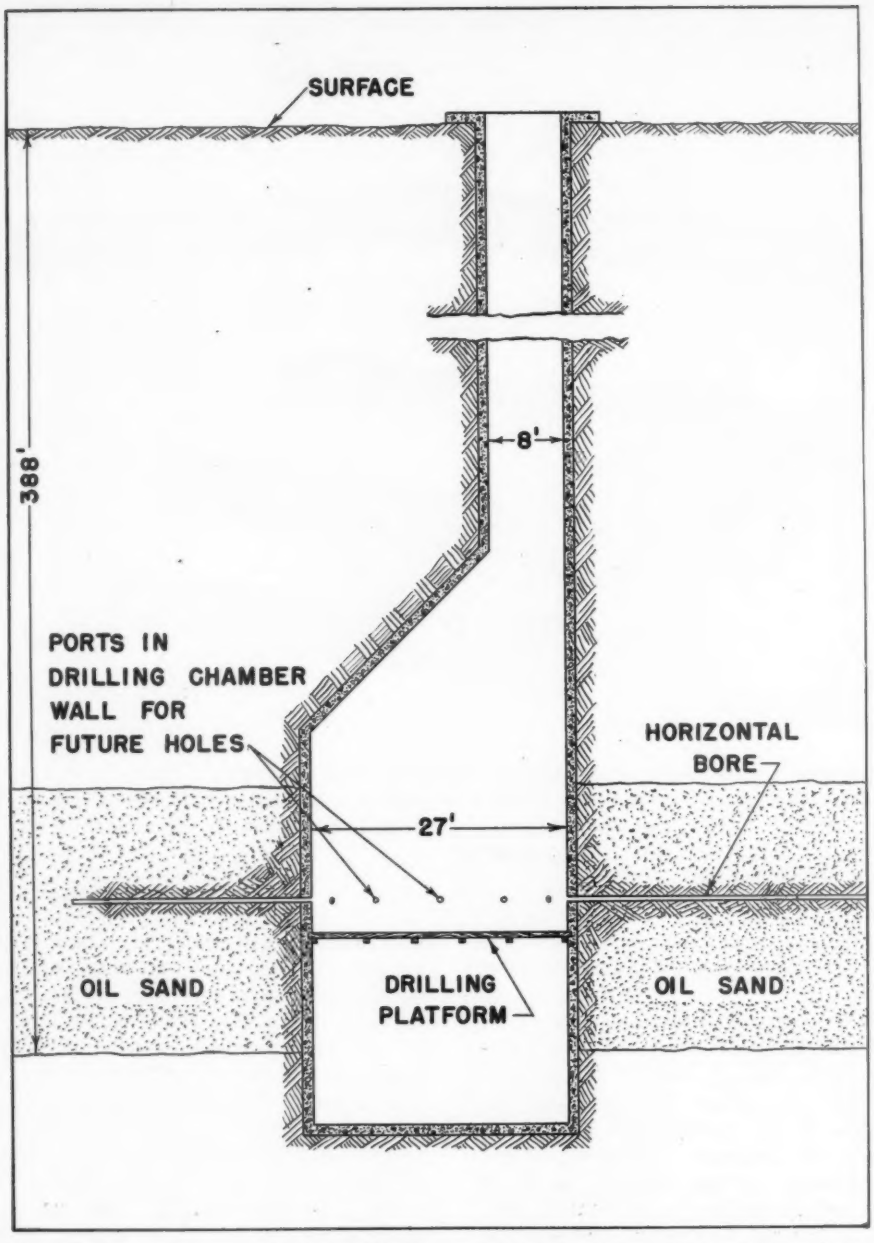


Sectional view of Ranney horizontal drilling chamber showing vertical shaft and horizontal holes radiating out into structure.

only 15 per cent. No serious difficulties were encountered in drilling any of these holes, in fact the drill rods never were stuck.

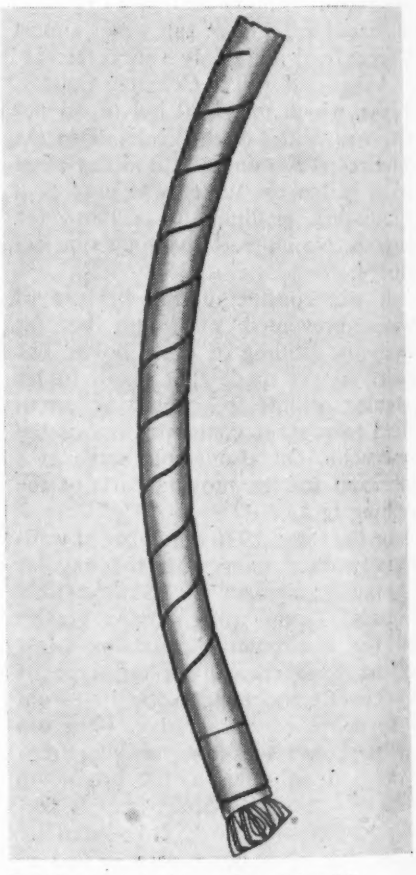
In May, 1942, a program of drilling horizontal holes from a shaft was begun in the Franklin Heavy field, Venango County, Pennsylvania. This reservoir had been produced by wells drilled between 1859 and 1861. Initial production of these wells ranged from 1 to 35 bbl per day. At the time of drilling the horizontal holes, the 20 wells on the 400-acre tract were producing 0.40 bbl of oil and 18 bbl of water per well per day.

A location was chosen near the center of the tract and a shaft was sunk to 388 ft. The concrete lined 8 ft diameter shaft was provided with a 27 ft lined working chamber at the bottom. From this chamber horizontal holes were drilled through ports in the walls. The first 100 ft of each hole drilled was 5-in. diameter and was lined with 3½ wrought iron casing with cement grouted in the annular space between the formation and the casing. Three-inch diameter hole was drilled thereafter. Two holes were drilled initially, one 2255 and the other 2334 ft. The drilling rate averaged 22 ft of hole per shift. Most of the distance was cored and an acid bottle survey run at 100 ft intervals and the holes kept at an upward inclination of about 1 in. in 10 ft.

Both drill holes were loaded with 80 per cent high velocity gelatin dynamite to within 400 ft of the shaft wall. In all 10,600 lb of explosive was loaded into the holes and detonated. The holes were cleaned out for their complete length by use of a perforated pipe and reverse circulation of water. Rock fragments were flushed into the tool and were removed. Part of one hole was redrilled with a fish-tail bit to remove a bridged section.

Due to excessive costs of drilling the first 2 holes, the original plan for drilling 24 long horizontal holes radially from the shaft to drain oil from the whole 400-acre lease was abandoned. Ultimately, four 1000 ft laterals and four 600 ft horizontal holes were drilled. The first 2 long holes produced by gravity and 1 month after the drilling was completed, total production from the holes was 20 bbl of oil per day. This was considerably more oil than the 20 conventional wells yielded and their production was not affected. Later 15 points of vacuum was applied to the horizontal wells which increased production considerably. In September, 1944, the vacuum was increased to 21 points and it was reported that 126 times as much oil per acre day was extracted from the sand as the vertical wells had yielded in 1940. In March, 1945, the horizontal bores still were producing 20 bbl of oil per day and 80 bbl of water. In 1948 it was reported that the 2 longer holes had plugged and were no longer producing. Ten barrels of oil per day was the total yield of the shorter laterals.

While Ranney was drilling horizontal wells from shafts another inventor became interested in drilling laterals.



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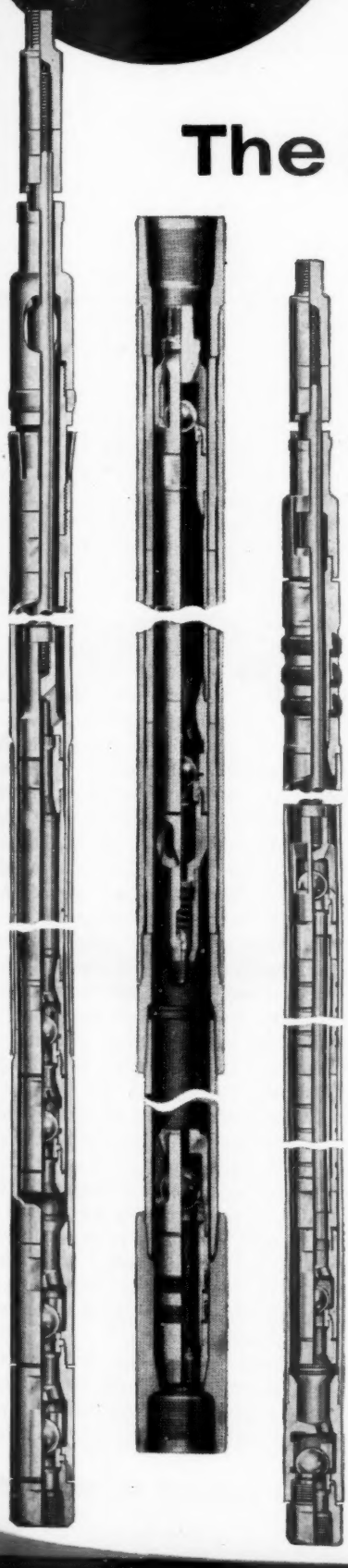

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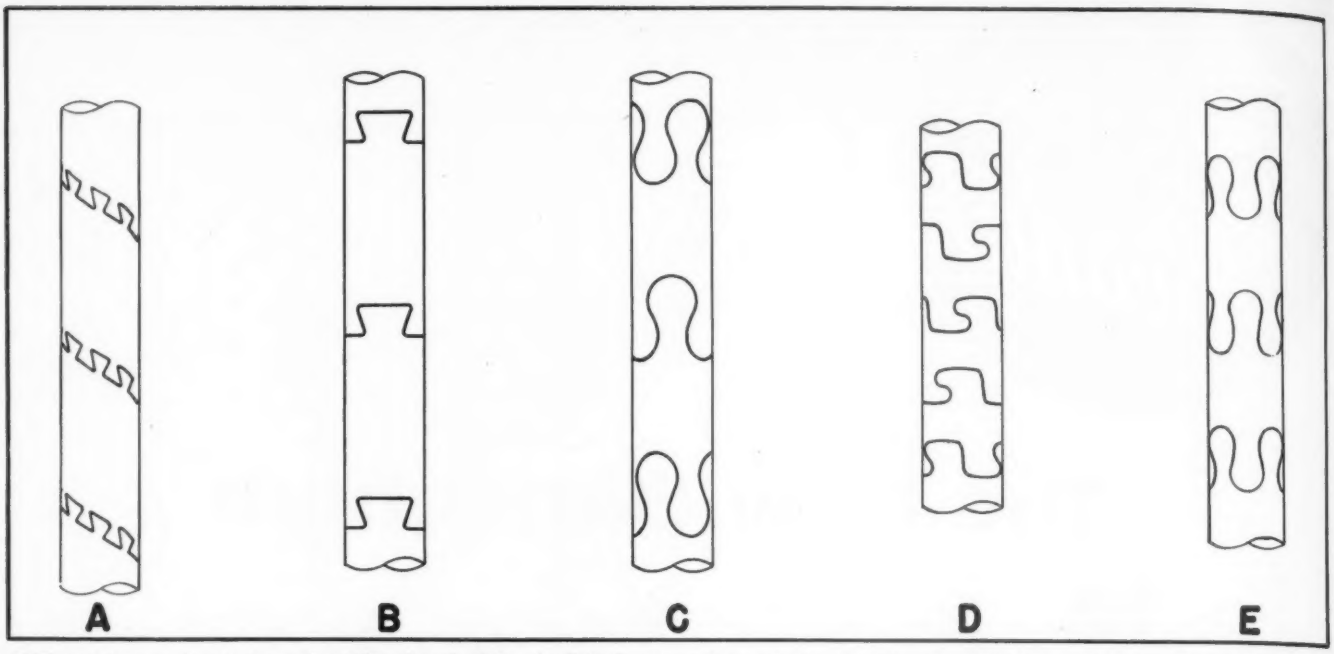


Different types of cuts to make drill pipe flexible. A. Spiral cut used on Zublin's flexible drill pipe. B. Keystone or dovetailed cut used on Eastman flexible drill pipe. Note that center of lobes is staggered 30 deg between each cut to prevent pounding of pipe when rotating. D. Experimental type cut for maximum flexibility. E. Four lobe type cut used on Oil Well Drain Hole Drilling Company's flexible drill pipe.

John Zublin, inventor of a novel type of rotary bit, turned his attention to the problem of digging laterals from the main bore of an ordinary well.

Zublin's first patent application was filed in December, 1941, on a tool to drill laterally from the main bore into the productive zone. It consisted essentially of three different pieces of heavy drilling equipment. Two types of flexible drill pipe and a fluid-operated turbine motor with a special bit were designed to dig the lateral holes. It was not planned to rotate the pipe. It was to act as a guide for forcing the bit to penetrate out of the main hole and was made flexible so it could follow the curved course of the bit. A number of sections of the best grade of drill pipe available were given the elasticity and resiliency of spring steel by special heat treatment. A continuous spiral slot was torch cut through the wall of the drill pipe over its entire length except for a 15 in. section at each tool joint end. This made the pipe flexible so that it could be run into a curved hole, but it would return to its normally straight form when not forcibly bent. Each section was lined with high pressure hose which was riveted at the ends of the flexible pipe to conduct fluid without leakage. One special curved type section was manufactured. It was similar to the flexible sections except that it first was bent to a definite radius of curvature and heat treated to retain its curved form. The turbine motor and bit assembly was as short as possible (20 in. length) and was attached to the bottom of the curved pipe for drilling.

This equipment was used in the following manner. As many lengths of straight flexible pipe as was needed to drill the length hole desired was made up on the conventional drill pipe or tubing to be used in laterally drilling the well. The single section of curved resilient pipe was made up on the bottom of the flexible pipe and the turbine bit was screwed onto the bottom of the curved pipe. This drilling assembly was lowered to the open hole and the tool was turned to face the bit in the direction in which it was desired to dig the drain-hole. Drilling mud of high viscosity was pumped down through the drill pipe into the turbine motor which rotated the bit.

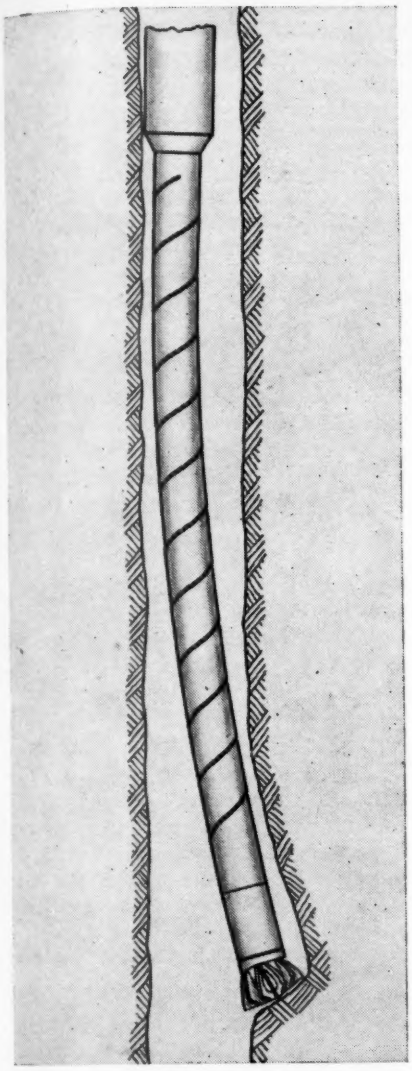
As the curved pipe tended to resume the curvature to which it was bent and heat treated initially it pressed the bit against the side of the main bore with considerable force. As the bit rotated, it cut a side pocket in the vertical bore and gradually dug a lateral outward and downward from the original hole. As the bit dug the pipe was lowered to crowd the bit. The inherent resiliance of the curve pipe made the angle in the lateral increase due to side pressure on the bit. The flexible drill pipe and curved pipe were not rotated; they merely conducted the fluid to the turbine. The curved pipe forced the bit to bite into the wall of the original hole and the flexible sections followed the pipe into the curved lateral as drilling proceeded.

Zublin's equipment was the first which did not employ a whipstock to deflect the new hole away from the main bore. If it was desired to drill a straight section beyond the curved lateral hole, the assembly was withdrawn from the hole and the curved pipe removed. Drilling was resumed with the bit on the flexible pipe. Zublin's second patent covered a simple mechanism for forcing the bit to enter the mouth of a lateral already partially drilled.

Considerable difficulty was experienced in straightening the resilient curved pipe enough so that it could be run down through the casing and into the open hole. This objection was overcome by straightening the curved section in a clamping device before it was run into the hole. As it was held in this position a stiff cylindrical mandrel was inserted into the curved pipe which reduced its curvature. After the assembly was run to the desired depth in the well, an overshot lowered inside the pipe on a sandline retrieved the mandrel. The resilient pipe then assumed its curved shape, pressing the bit against the side of the hole to start the lateral.

Drilling was done with very light mud or clear water. About 300 to 400 gal of fluid per minute was delivered to the bit with a slush pump under 600 to 700 lb pressure. Weight carried on the bit was very low; never over 3000 lb. An efficient mud screen shaker was needed to remove all abrasive sand from the fluid to minimize wear on the turbine bit.

This equipment was tried experimentally on two wells in the Midway-Sunset field in California's San Joaquin Valley. Oil zones between 1100 and



Turbine bit starting to dig lateral. Resiliency of the curved pipe forces bit to one side of hole.

1500 ft depth were drilled with drain holes after windows had been cut in the liners at the correct depths. Curved pipe bent to a 20 ft radius forced the turbine bit out through the windows. Three drain holes were drilled in one well in lengths from 52 to 72 ft.

Eight drain holes were drilled in one shallow well in the Midway district which originally was drilled and completed in a conventional manner in 1918. It produced until 1928 when it was shut down as the daily production had declined to 1 bbl of 12 to 14 deg gravity crude per day. Seventeen years later, in 1945, the well was sidetracked and 8 drain holes were drilled in the oil zone below the 12½-in. casing. Four hundred twenty-one feet of laterals were drilled each one averaging 53 ft in length. Light weight mud was circulated to operate the turbine bit and wash the cuttings from the hole. Pump pressures varied between 400 and 600 lb. The speed of drilling varied considerably but it averaged about 1 ft per minute. After the drain holes were completed the fluid level stood 300 ft off bottom. Daily production increased from 3 bbl immediately after drilling to 25 bbl per day, a month and a half after the workover. Production of sand dropped from 35 per cent to 8 per cent during this same period. It is reported that the well produced 20 bbl of oil per day for a number of years.

The same tools drilled a total of 458 ft of laterals at depths from 1650 to 1680 ft in a well in the Round Mountain field in Kern County, California, in July 1946. The well bottomed in an 80 ft thickness of oil sand at a depth of 1720 ft. All of the 9 laterals were drilled below the 8⅝-in. casing in open hole and were oriented with 2 holes in each quadrant. Three of the holes were drilled in a S 19 deg E direction as one was very short. The longer holes averaged 56 ft each. This work was completed during a period of 4 working days. The penetration rate was about 30 ft per hour using crude oil as a power fluid for driving the bit.

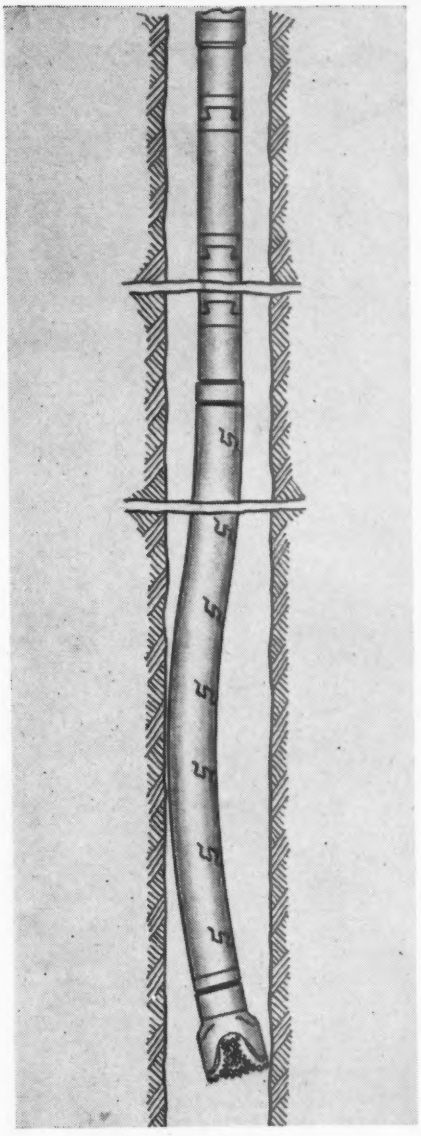
In 1947 the helical slot cut in the pipe was redesigned to give it more strength since laterals were being drilled in deeper wells. Experience had shown that the helically slotted flexible pipe with a smooth edged slot deformed badly under excess weight. If enough weight was applied, the upper section expanded and telescoped over the next lower spiral section ruining the pipe and causing the hose inside to burst. The new slot still followed a spiral path around the pipe but was cut in the shape of interlocking dovetailed teeth. Each tooth had straight sides diverging from its root and it terminated in a straight edge parallel to the helical path of the slot. Thus, when the pipe was compressed, the inter-meshing teeth prevented it from failing.

Sometime in 1948 use of the turbine bit was abandoned and the tools were redesigned so that ordinary rock bits could be used for drilling. The fluid propelled motor and bit were eliminated entirely, and the flexible and curved pipes were made to rotate a tricone bit rather than to function as a guide.

Recently Zublin has received coverage on the use of his drill guide and flexible drill pipe off a deflector to assist in starting the lateral hole in hard formations.

Eastman lateral drilling equipment incorporates some ideas derived from experience gained in directional drilling. A universal knuckle joint is used to force the drilling equipment to increase drift as its digs.

Two sizes of lateral drilling equipment are available. The 4¾-in. lateral



Modern Zublin lateral drilling equipment. Flexible drive pipe above with drill guide below. Tricone bit is rotated by inner drive pipe, (not shown). Drill guide itself does not rotate normally. By its resiliency it forces the bit to drill laterally upward.

tools are designed to use a 4¾-in. diamond or rock bit cutting laterals from a 6 to 6¼-in. main bore. The 3¾-in. tools are made to use a 3¾-in. bit to dig laterals from smaller main bores. Only the 4¾-in. tools will be described as the smaller tools are practically identical except for size.

The lateral drilling tools consist of two separate assemblies; a whipstock and protective casing assembly and a drilling tool assembly.

The protective casing is 5½-in. OD 17 lb casing in lengths with internal and external flush tool joints. The amount of protective casing may be varied according to the situation in the individual well and the length lateral it is proposed to drill. The amount of casing used always is longer than the lateral to be drilled so that the flexible

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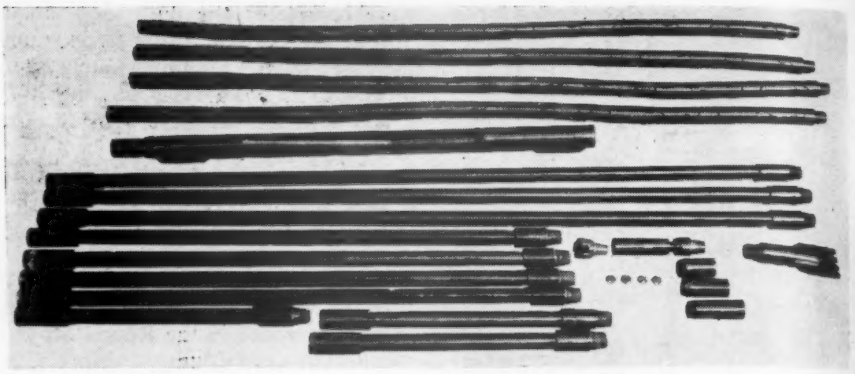

Eastman lateral drilling tools — top are 4 flexible collars run in above the whipstock which allows the bit to deviate rapidly. Below is special whipstock which forces bit to drill laterally. Lower left are various lengths of 3½ in. drill pipe used as tail pipe to set whipstock at any desired depth off bottom. Lower right are tricone drilling bit, knuckle joint, and various subs. The anchor bit used on bottom to prevent the whipstock assembly from turning also is shown.

drill collars are kept from keyseating in the main hole. Often enough casing is used so that it extends up into the casing string set in the well thus safeguarding the well in event of a fishing job. A shear pin casing nipple is screwed into the top of the casing assembly. The nipple is equipped with a threaded hole and pad to accept a steel shear pin which screws through the casing and into a shear pin sub in the drilling tool assembly.

Made upon the bottom of the protective casing is the whipstock section 5½-in. OD and about 10 ft long. The tapered section of the whipstock face is 3 ft 8 in. long and is curved in radius to cause the drilling bit to dig upward and increase angle. The whipstock has a triple purpose. It forces the bit to increase angle at a uniform rate and insures that the point of deviation from the main bore is at the exact depth desired as well as insuring that the bit starts in the right direction. No time is wasted in forming a shoulder to start the hole, since the bit is forced to dig laterally as soon as it is rotated and weight is applied. Use of a whipstock insures that the lateral is started in the correct direction.

The bottom of the whipstock section is equipped with a tool joint pin to accommodate the box in a releasing sub run below it. The releasing sub is interposed between the whipstock section and the tail pipe as a safety feature. If the tools should become stuck in the hole, the sub releases on a 15,000 lb straight pull. Thus the whipstock and protective casing can be withdrawn from the hole and the tailpipe fished if it becomes stuck. The tail pipe consists of lengths of 3½-in. drill pipe with external flush tool joints. Tail pipe sections vary from 5 to 30 ft in length so the whipstock can be set at any distance off bottom desired. An anchor bit is screwed on the bottom of the tail pipe. Slots cut in the face of this bit cut into the formation at the bottom of the well and prevent the assembly from turning after it is once set. Circulation holes provided in the bit make it possible to circulate to bottom if the tailpipe must be fished from the well. The whipstock and protective casing assembly serves to start the drilling tools in the correct direction at a uniform rate of increase in angle and at the depth at which the lateral is planned. It also encases the flexible drilling tools so they are protected in the main bore as the bit digs the lateral.

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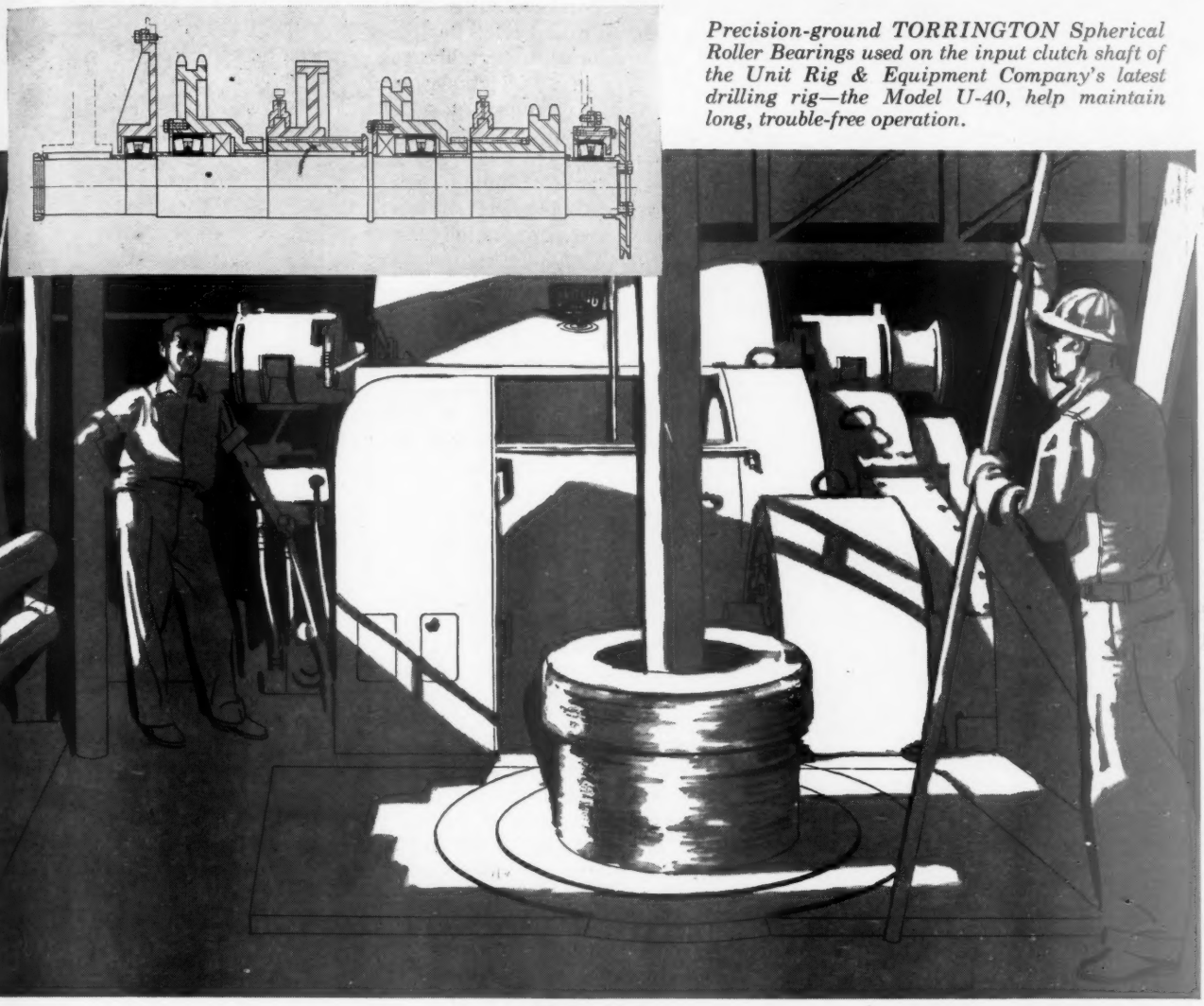

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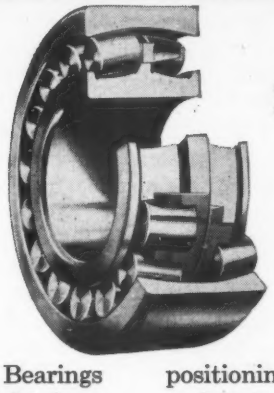

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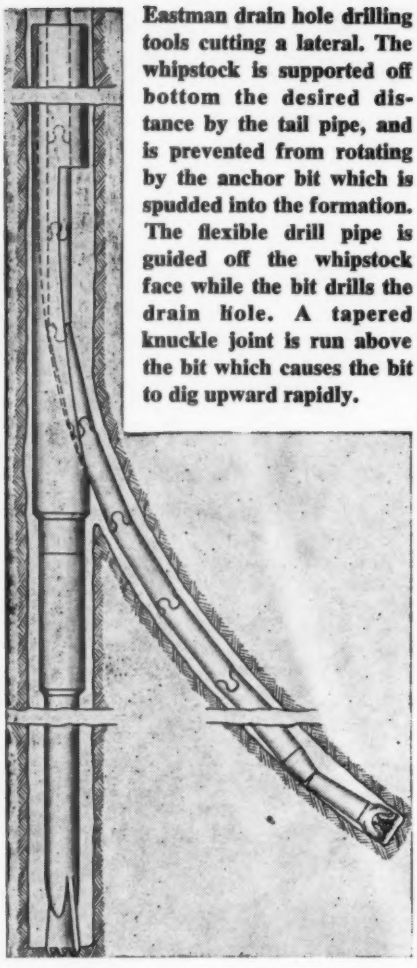


Eastman drain hole drilling tools cutting a lateral. The whipstock is supported off bottom the desired distance by the tail pipe, and is prevented from rotating by the anchor bit which is spudded into the formation. The flexible drill pipe is guided off the whipstock face while the bit drills the drain hole. A tapered knuckle joint is run above the bit which causes the bit to dig upward rapidly.

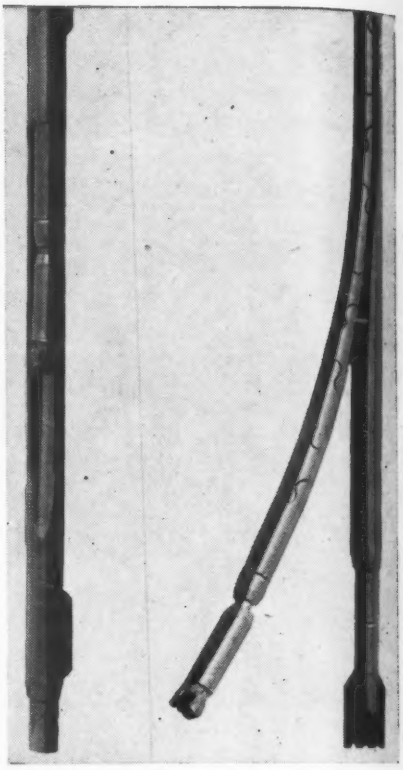
The drilling tool assembly consists of a shear pin spiral sub, a number of flexible drill collars, a universal knuckle joint, a short spiral reamer, and a rock or diamond bit. The flexible drill collars are approximately 16 ft length sections, 4¼-in. OD with a 2-in. internal bore. These flexible sections are made from standard drill collars with 2⅞-in. API internal flush tool joints. A special type of 3 lobe clover leaf cut is made through the collars on 9⅛-in. centers. Cuts are made with a torch and template which guides the torch. The width of the cut is regulated carefully to limit the flexibility of the pipe. A wide cut makes the pipe very flexible; a narrow cut reduces the radius on which the pipe may bend. In cutting the clover leaf or three lobe design the flame of the torch is pointed at the center of the bore of the drill collar at all times. Thus the outside of the lobe is larger than the inside. This feature prevents inter-engaging sections from separating.

The lobe pattern is not spiraled around the pipe but is formed perpendicular to the long axis of the drill collar. As each set of lobes are cut the template is rotated 30 deg around the pipe so lobes are not cut from the same starting points. Being staggered at 30 deg intervals, every fourth joint cut is in alignment. Thus the pounding of the flexible joints as they are rotated in drilling is eliminated. The drill collars are heat treated to relieve stress after the torch cuts are made. Each flexible collar is lined with a rubber tube to carry fluid to the bit. The circulating hose is 1000 lb test Neoprene rubber with couplings at each end. Provision is made for the hose to slide as the drill collars are flexed. Sliding seals made tight with "0" rings prevent circulation leaks. These connections have been designed to facilitate the changing of hose at the rig in a minimum of time.

All of the flexible drill collars are identical in construction. The number of flexible drill collars used in the drilling assembly varies with the length lateral to be drilled. At least 10 ft more flexible pipe should be used than lateral length. The shear pin spiral sub is made up between the flexible collars and the ordinary drill pipe or tubing used for drilling. The sub has a hole drilled and tapped in its side to receive the shear pin which is screwed through the shear pin casing nipple into it. A set of spiral blades cut off the broken end of the shear pin as the sub drills by. A universal type knuckle joint is run between the bottom of the flexible drill collars and the digging bit. The knuckle joint transmits torque from the flexible collars to the bit through drive pins in a ball and socket joint. A circulation hole is provided down the center of the universal joint to carry mud to the bit. The diameter of the knuckle joint reduces toward center from both ends. The relation of the greater and lesser diameters and the length from the face of the bit to the pivot point of the knuckle joint is quite critical and varies the limit of the ability of the bit to dig upward.

When weight is applied to the assembly the bit tends to cut out the upper side of the hole making the drift angle increase rapidly. Most drilling setups are built to dig upward at the rate of 2 deg increase per foot which makes the lateral turn upward on a 30 ft radius. For most soft and medium formations a tricone rock bit is used. Whenever the formation is suitable, laterals are cut with a diamond bit. In some cases a very short spiral reamer is run between the bit and the knuckle joint which acts as a fulcrum as weight is applied to the drilling assembly forcing the bit face to incline upward. This action causes the angle to increase and the spiral ribs ream the hole to gage reducing binding of the flexible collars as the lateral deepens. The length and diameter of the reamer is critical and must bear a relationship to the diameter of the knuckle joint and bit.

The lateral drilling tools are used as



Eastman drilling tools as they appear when bit is in position to drill off whipstock and initiate lateral hole are shown at left. Bit and knuckle joint are guided by whipstock face which causes bit to dig in the chosen direction. Right photo shows position of lateral drilling tools after drain hole is well started. Knuckle joint above bit is fully flexed to force bit to dig upward.

follows: The whipstock section and releasing sub are made up and the required amount of tail pipe (varying with the bottom depth and the depth at which a drain hole is to be drilled) is screwed onto the sub. The anchor bit is made up on the bottom of the tail pipe. Sufficient length of protective casing to house the required number of flexible drill collars is made up on top of the whipstock assembly with the shear pin casing nipple on the upper end of the casing. Then the shear pin sub is made up on the drill pipe or tubing to be used for drilling the lateral and flexible drill collars screwed onto the sub. The universal knuckle joint and bit are screwed onto the bottom of the flexible collars. The drilling assembly is lowered down through the protective casing assembly until the hole in the shear pin sub and the shear pin casing nipple coincide. A shear pin is screwed through the nipple into the sub. This connects the two assemblies together.

If the tools are to be oriented from the surface, the whipstock is faced in a known direction and orientation is carried on as the assembly is lowered into the well. When bottom is ap-

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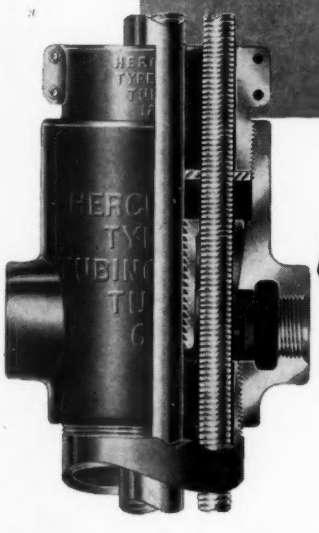

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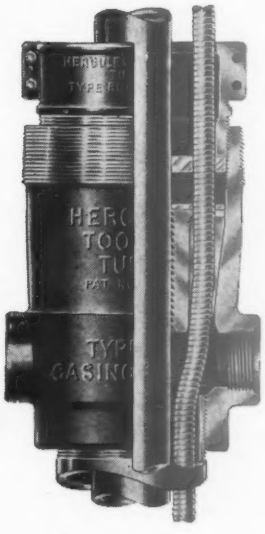

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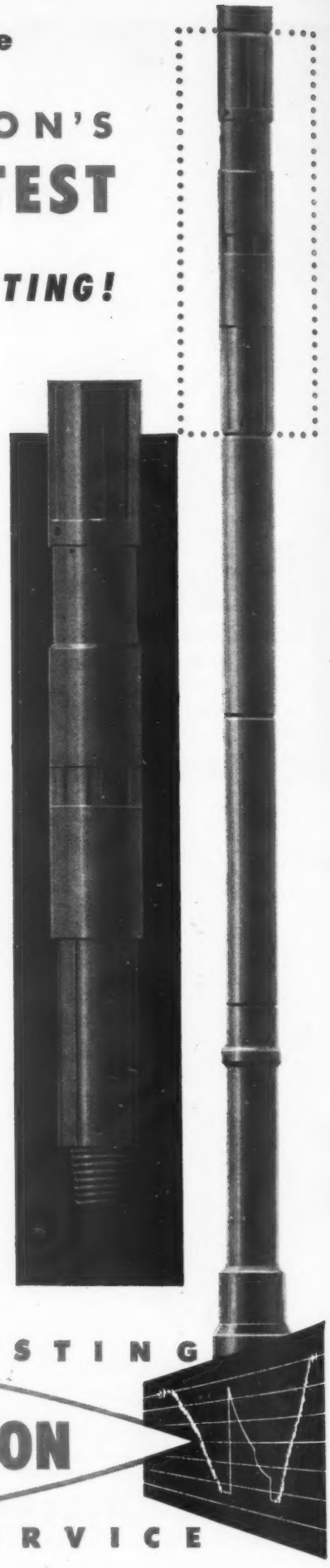

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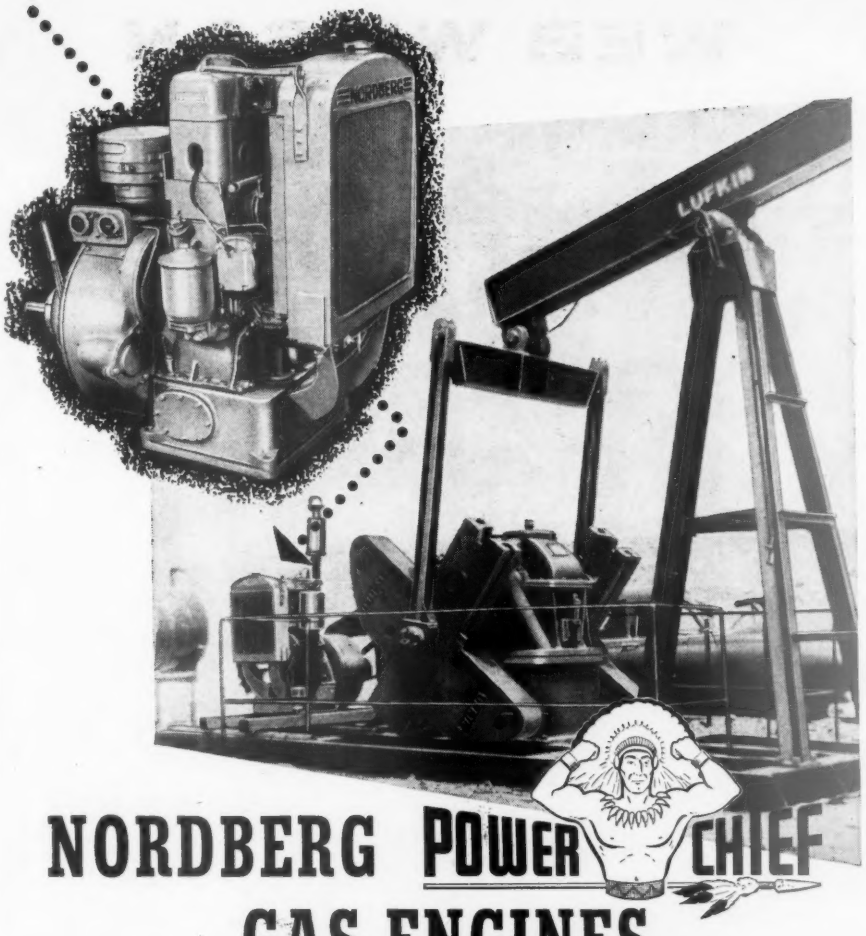
proached the tool is faced in the desired direction and spudded on bottom to seat the anchor bit in the formation at the bottom of the well. Further application of weight shears the pin so that the drilling assembly is free to rotate. The drilling tools are lowered so that the bit lies on the face of the whipstock and circulation is established. The drilling string is rotated at about 60 rpm and lowered to start digging. The whipstock forces the bit to incline upward and guides it in initial direction. After the bit drills off the whipstock, more weight is applied to crowd the knuckle joint to the bottom of the hole and force the bit to drill upward. The bit is lifted off bottom occasionally as drilling proceeds to circulate the hole clean.

As soon as the required length of lateral has been dug the tools are hoisted out of the drain hole. The whipstock and protective casing assembly may be left in the well temporarily or brought out with the drilling-assembly. When digging in hard formation where more than one bit is dulled in drilling lateral, or if a liner is to be run, or the hole is to be surveyed, it is desirable to leave the whipstock in place in the well until all of the operations are completed. In this case the whipstock and protective casing assembly are finally retrieved with a casing spear run on the drill pipe. In softer formation where one bit will drill a drain hole and no liner is to be set or survey made, a lifting sub is run below the shear pin sub which brings the whipstock and protective casing assembly out of the well when the drilling assembly is withdrawn.

The use of a whipstock has decided advantages. Whenever it is necessary to withdraw the drilling assembly to change bits or check the equipment the whipstock left in place in the hole guides the tools back into the lateral. A flexible liner run into the drain hole after completion likewise is guided into the lateral without probing. If a survey is made the barrel enters the hole easily. In no case has any trouble been encountered in retrieving the casing assembly with a spear after any of these operations. No tail pipe has been stuck in the well; use of a releasing sub is only a safety feature in case the tail pipe should stick.

Crude oil or oil-emulsion mud is recommended as a circulating fluid in lateral drilling but two holes were successfully drilled with gas. Laterals have been drilled successfully in both hard and soft formations with these tools.

The Oil Well Drain Hole Drilling Company uses drilling tools somewhat similar to those described above. One of the main differences in their equipment is that the flexible drill pipe is made with a four lobe cut. * * *



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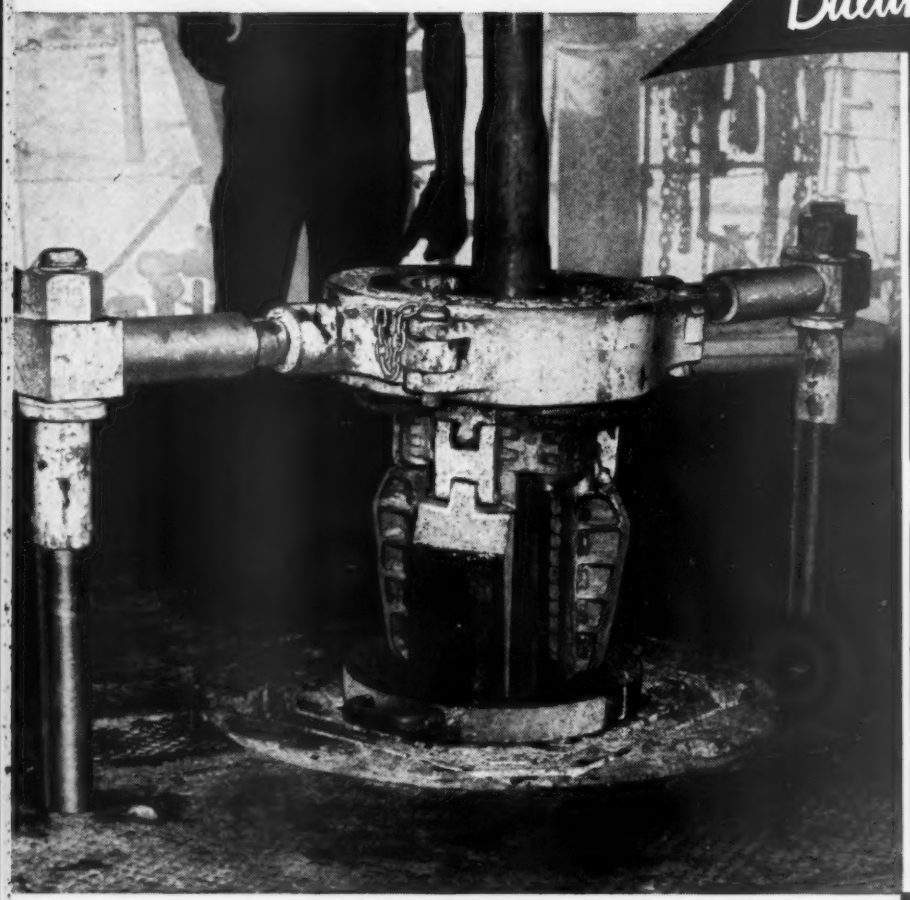

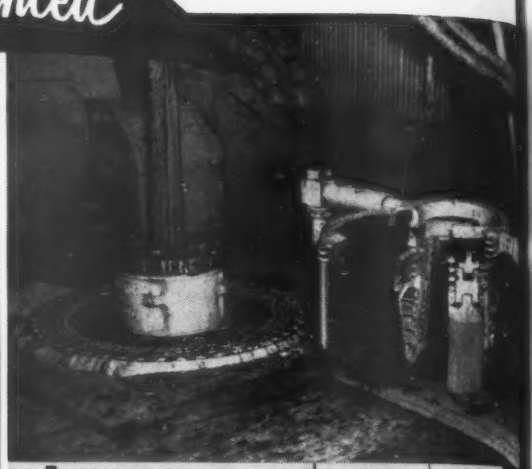

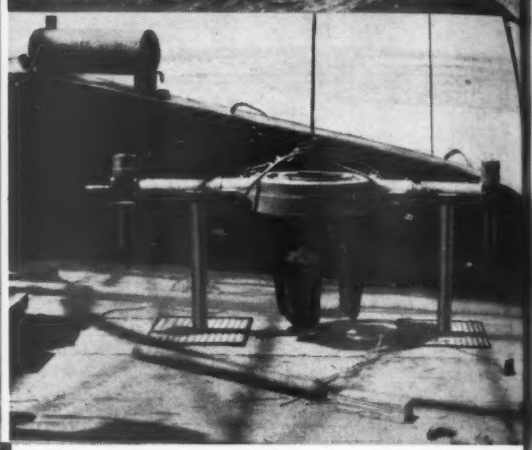

(TOP) Showing slip assembly swung away from the rotary table on one of the supporting posts; the other has been retracted and covered with steel safety plate. (BOTTOM) Slip assembly has been lifted by the catline and set on the stand provided; *both* posts have been retracted and covered with steel safety plate.

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Chemical Removal of Paraffin From Wells

Economical cleaning of lead lines, tubing strings, and tanks may often be effected by proper solvent application

GUY F. WILLIAMS*

CONSIDERING the many kinds of paraffin accumulations and the variety of well conditions in which they may be encountered, it is imperative for an operator not only to choose the right chemical solvent, but also the right method of application to meet each condition.

Types of paraffin encountered vary greatly in chemical composition and characteristics. In some fields the accumulations are almost pure paraffin which can be dissolved with little difficulty if a suitable solvent is selected and applied properly. Sometimes, however, the deposits contain foreign substances which make satisfactory removal a more complicated matter — for example, asphalt, sand, gums, and waxes.

Before a paraffin solvent treatment is made, there should be good reason to believe the subject selected is being affected because of paraffin. A sample of the paraffin from the particular well, line or tank bottom should be tested in various solvents, and the solvent that gives the most complete removal should be used.

In order to get any penetration through paraffin or oil, which is always present, the solvent used must be heavier than the paraffin or oil in question. The proper mechanical application must be followed and the solvent must be brought in contact with the paraffin deposit in order to get satisfactory removal.

The first step in deciding upon a method of treatment is to make a careful study of the well, line, or tank in order to determine the location, amount and condition of the paraffin deposit. When deposits have been built up gradually over a period of months or even years, they are usually very hard and dense. In such instances the procedure requires more time than if the deposit is soft and plastic, and more than on application of chemical solvent may be necessary.

Chemical solvents for the economical removal of paraffin deposits have been used successfully for many years, but they are by no means a cure-all for this trouble which affects the majority of wells. If proper procedure is not followed, satisfactory results cannot be expected.

*Bulk sales manager, Dowell Inc.

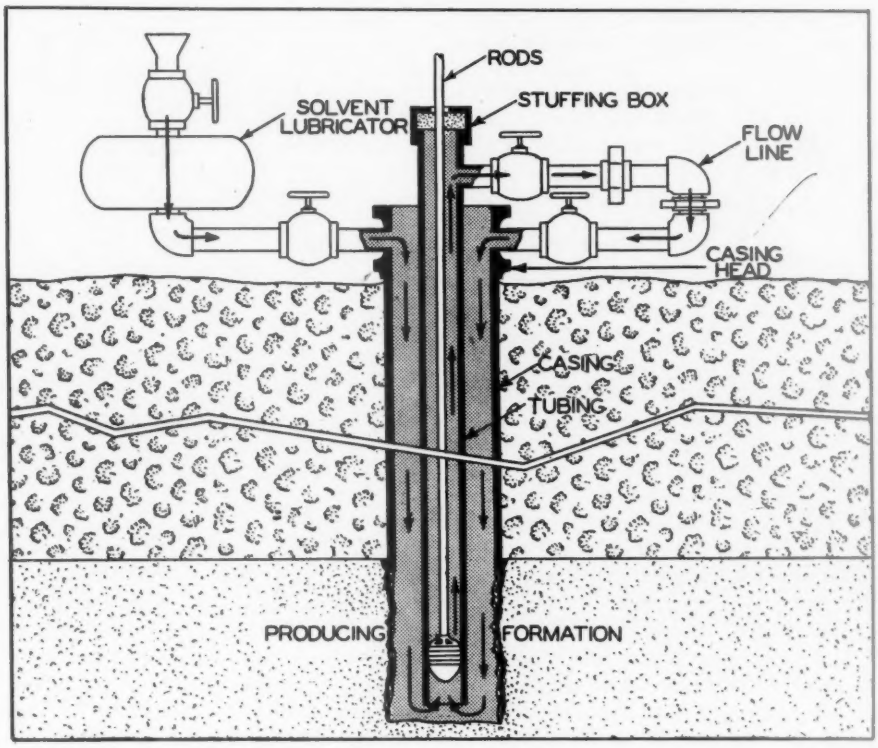

FIG. 1. The circulation method of applying paraffin solvent. Solvent is introduced down the casing and circulated up the tubing.

Application Methods for Solvents

The following are some application methods based on field experience over a number of years:

To remove paraffin from pumping wells without pulling rods or tubing and where considerable gas is pumped with the oil, release back pressure at the trap and allow the tubing partially to empty itself.

Lift the stuffing box, insert a funnel and pour the chemical solvent in between the polish rod and the walls of the tubing.

When there is insufficient gas to unload the tubing, lift the rods sufficiently to unseat the standing valve, permitting the oil to recede down the hole. Introduce the solvent into the annular space between the polish rod and the tubing. Precede and follow the chemical solvent by oil in amounts equal to the amount of the solvent.

When the pump leaks at the bottom of the hole sufficiently to permit the oil to recede down the tubing, remove the stuffing box and introduce the chemical solvent into the annular space between the polish rod and the tubing.

In the circulation method, pump the well off as much as possible. Introduce the solvent down the casing and flush with oil. Then, connect the tubing flow

EXCLUSIVE

line directly into the casing-head (Fig. 1) close in the casing and circulate the mixture. Continue circulation for at least 12 hours, or 24 hours if possible. A treatment of this type usually cannot be made on a well which has over 125 lb pressure on the casing because the pump mechanism will not seat.

In all pumping well applications with the exception of the circulation method the chemical solvent should remain in contact with the paraffin accumulation approximately 4 hours, pumped up the well and dropped back down the tubing again, repeating the cycle until satisfactory removal has been achieved. In the circulation method, it is customary to circulate the well 24 hours. These are arbitrary practices and may be varied by the pumper to suit individual cases.

If the well contains an excessive quantity of tough paraffin, the circulation method should be used. If gas pressures interfere with the pumping during circulation, a vent may be installed on the opposite side of the head.

Application to Flowing Wells

In the treatments of this type and because the well is usually under pressure, a lubricator is used to introduce the chemical solvent into the tubing.

If paraffin is formed in the well less than 600 ft from the top, the solvent should be injected and the well left closed for from 6 to 8 hours. The well should then be opened wide for a short time to permit the chunks of undissolved paraffin to flow out, after which the well may be returned to normal operation.

If paraffin is formed deeper than 600 ft, the treatment should be effected in stages. Lubricate the chemical solvent into the well and let it stand for 4 hours and until the well builds up to its normal pressure. The well should be opened and allowed to flow for a short time. Repeat the procedure, permitting the solvent to remain in the well at least 6 hours and after repeating the process for a 3rd time, the well may be returned to production.

The rocking method is used in wells producing large quantities of natural gas. In these wells the gas will collect in the top of the tubing when the well is shut in, as the fluid level gradually recedes down the hole. The chemical solvent mixture should be heavier than oil and introduced into the tubing through a lubricator. With the well completely shut in the solvent should be left in the well from four to six hours. Then, by bleeding off the gas, lift the solvent up to the well head. Shut down for a second period of from 4 to 6 hours and, if time permits, repeat the procedure and then flow out the chemical solvent.

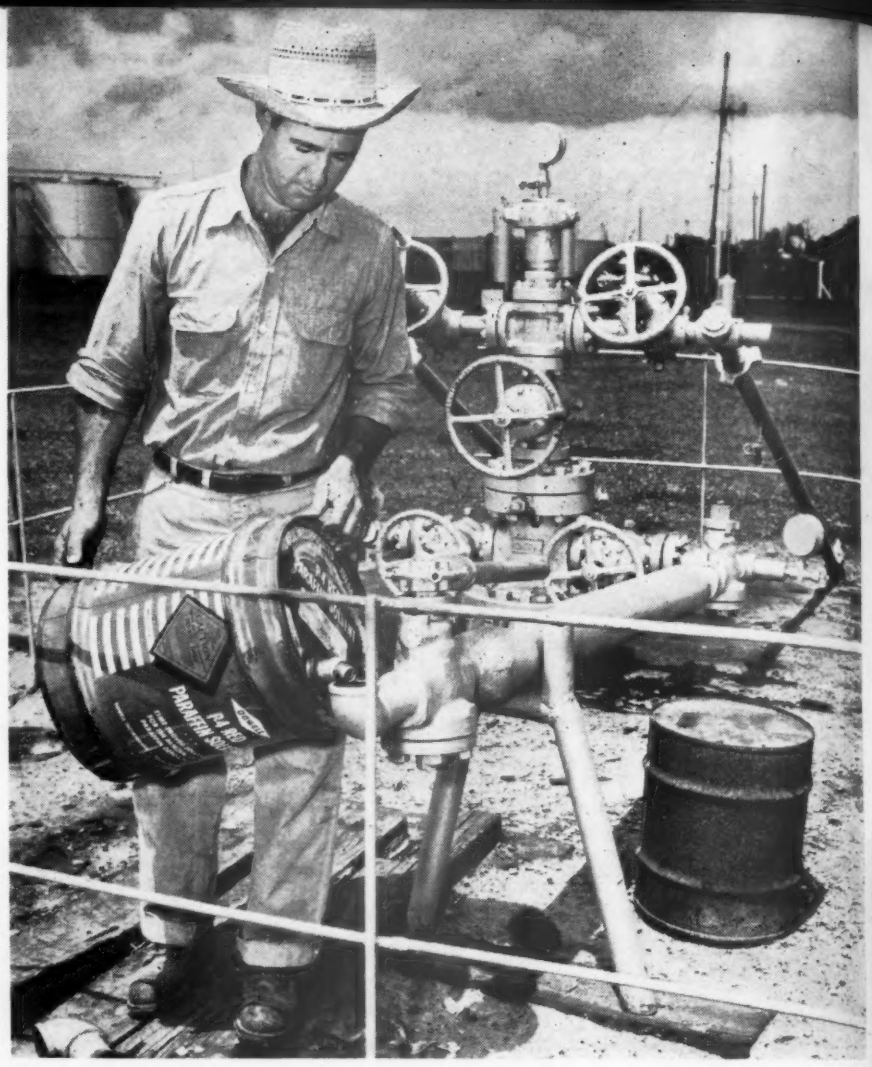

FIG. 2. Typical lubricator arrangement on a high pressure well. Paraffin solvent is being used to remove paraffin accumulations from the annulus.

If the lead line is paraffined, flow the solvent from the well through the line as slowly as possible by just cracking the valve into the tank. This procedure will often clean the lead line, thereby making double use of the chemical solvent.

In paraffin removal from periodically flowed wells the chemical solvent should be introduced through the lubricator immediately after a flow and permitted to remain in the well until the next flowing. When opened, the well should be allowed to flow vigorously.

In plugged flowing wells where gas comes through the bridge, lubricate 10 to 20 gal of chemical solvent into the well. Close the well in completely and let set until the well frees itself. If after 24 hours the well is not free, open the choke slightly and keep it open — the well will sometimes unplug. Aggravated cases of paraffin plugging may require two or three applications.

In plugged flowing wells with no gas leakage, lubricate from 5 to 20 gal of chemical solvent into the well. If there is casing pressure connect a line from the casing to the top of the tubing so as to use the pressure to force the solvent down through the paraffin. Let the solvent set from 2 to 6 hours. If the well is still plugged, run in a pointed or tapered weight, 3 ft or more in length, on a measuring line. Spud the line up and down by hand allowing the solvent to dissolve the paraffin as the weight penetrates the accumulation.

Bottom Hole Cleaning

In cleaning screens, liners and perforations, or producing formations, mix the chemical solvent with a carrying agent, making certain that the mixture is heavier than the oil or salt water in the hole Pump the well off as much as possible and introduce the solvent down the casing. Flush with a small amount of oil and let set for 2 hours. Then load the hole with oil until the bottom hole pressure is overcome and the solvent mixture feeds into the formation. Leave the mixture in the well over night and remove by regular production practice.

To insure penetration of the solvent into the formation in the above procedure, always use a greater amount of flushing oil than the amount of oil that was standing in the hole when the solvent was introduced.

In treating a well that makes gas, fill

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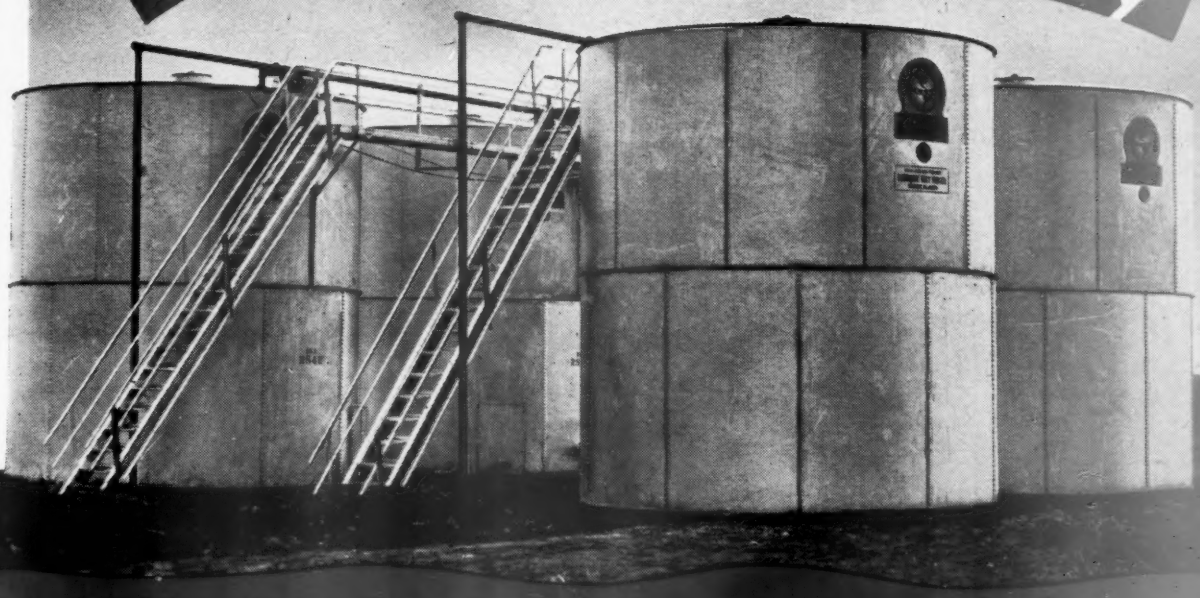

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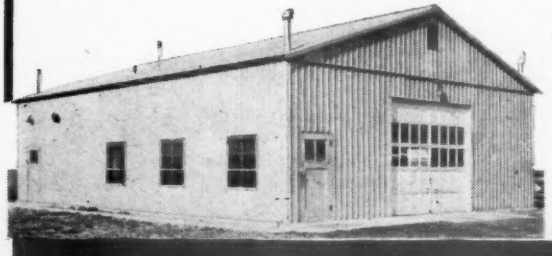

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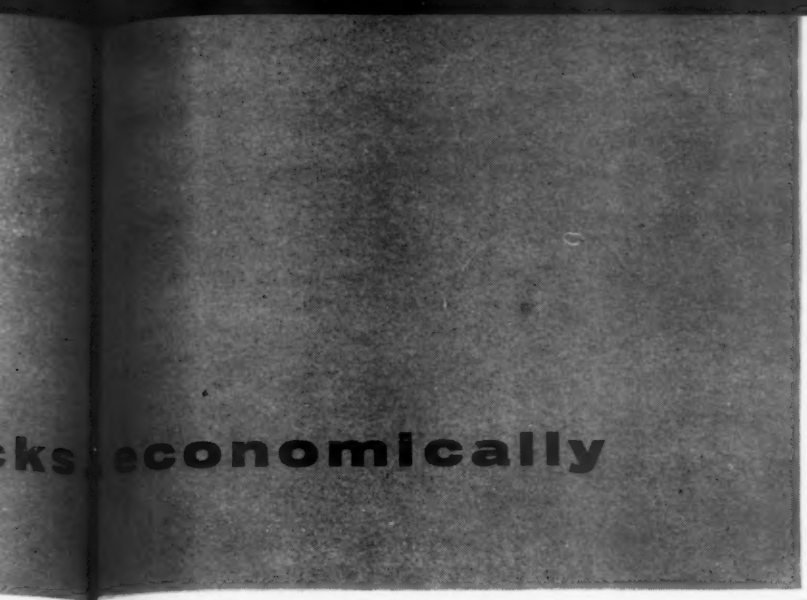

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the annular space with an oil load and close the well. Usually the gas from the formation will rise through the fluid and force the solvent mixture into the formation. This method of treatment has been quite successful.

In cleaning the producing formation, introduce chemical solvent down the casing and flush with a sufficient amount of oil to put on the bottom. Use enough solvent to cover the producing formation. Then shut the well in and leave it over night.

If it is desired to remove plugging materials in the critical area of a producing formation, the same procedure is followed with the exception that an additional amount of oil is used as a flush to overcome the rock pressure so that the solvent will feed into the formation. If the hole is filled and the formation still does not take the fluid, shut the well in. Usually, enough gas will bubble up through the load to force the fluid into the formation.

In the above treatments, the larger the amount of chemical solvent the better. It has been found that from 30 to 50 gal of solvent mixed half and half with kerosene and a small amount of emulsion breaker often gives good results.

In cleaning lead lines, introduce concentrated chemical solvent into the lead line through a lubricator or upright nipple as near the well as possible. Use large slugs of the solvent, the amount governed by the size and length of the line. Crack the valve on the end of the lead line and force the solvent slugs through the line either by pumping oil in behind the solvent or by using gas.

If the above procedure is followed, the solvent should come in contact with the paraffin at all points in the line. The longer the time allowed for the solvent to go through the line the better. A minimum of 24 hours should be allowed for a line 1500 ft long.

In cleaning a badly plugged line use a small slug of solvent first to open the line gradually and prevent clogging. Then follow with a larger amount of solvent. In cleaning large lines where large volumes are needed, mix the solvent with three parts gasoline or kerosene.

In preventing formation of paraffin in a clean line, a slug of solvent application usually works better than the forced-feed, drop-lubricator treatment. Periodically, as needed to keep the line clean, put solvent through the line in 15 to 25 gal slugs, or in whatever amounts are economical in the particular case.

To clean the lead line with the solvent already used in the well, pump the solvent slowly through the lead lines with the valve into the tank barely cracked. If the accumulation in the line is not too bad, and if enough time is allowed, this procedure may clean the line, thereby making double use of the solvent.

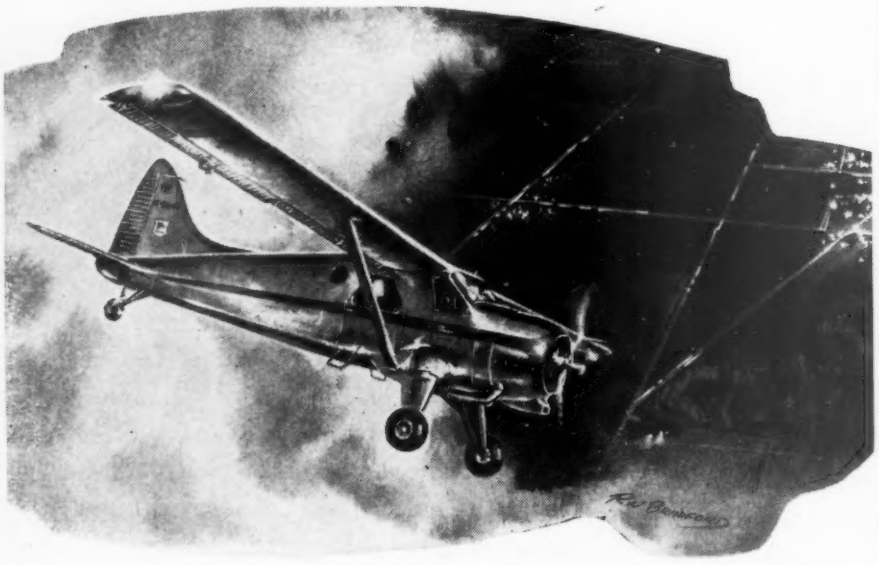
Paraffin Removal From Tanks

Expose the bottom of the tank down to the back gauge or pipe line connection. Distribute the solvent over the bottom by dipper or spray pump from the thief hole or manhole. Close the thief hole and manhole covers and let stand 10 to 12 hours.

After the closed-in period, drain off any water from the bottom connection and run in about 12 in. of fresh, live oil. Roll the bottom from the manhole, using gas or motor exhaust applied through a hose with a long small-diameter pipe attached to its end.

Continue until the paraffin is all in solution. Move the pipe around to all parts of the tank bottom to insure proper mixing. Fill the tank, and run the oil as soon as possible. Avoid breathing fumes from the manhole.

In cleaning a tank bottom, it is particularly important to test a sample of the paraffin to determine which solvent is most effective. The solvent must be heavier than the oil in the bottom of the tank. Good results are usually not obtained when the bottom contains more than 7 per cent water. * * *



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Development of Subsurface Combustion Drive

A report on research and background leading to anticipated high recovery from "in-situ" burning

DON V. HESTER and D. E. MENZIE

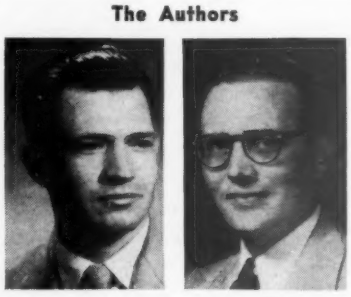
THE idea of applying heat to the reservoir to obtain increased recovery of crude oil is not a new one. There have been numerous proposals ranging from injection of steam to the use of electricity to heat the reservoir. Although none of the field tests run have definitely proven to be economically successful, the data and ideas obtained by them and the laboratory tests preceding them warrant considerable study in relation to the present stage of development of subsurface ("in-situ") combustion drive.

One of the first uses of heat as an aid to recovery was to melt paraffin from the well bore of a producing well.[14] Several sources of heat were proposed and used to varying degrees for this purpose. Chemicals which were dumped into the well, where they reacted with water to generate heat, included calcium carbide, sodium peroxide, and a mixture of sodium hydroxide and aluminum. Steaming was used to melt paraffin with no great amount of success.

The method of melting paraffin of greatest interest to the research reported in this paper is that of burning. As early as October, 1920, the Smith-Dun Company used this method near Marietta, Ohio. Air injection was being used in the field tested hence oxygen was present in the producing well bore. A fire was purposely started in the well by dropping burning oil-soaked waste into the well. After burning at the bottom of the well for 24 hours the flame was extinguished by pouring water in the top of the well. The rate of production increased about 100 per cent.

The Hope Natural Gas Company used a similar, more refined process in which a compressed air-gas mixture was pumped into the well through the tubing, and through an orifice into the "combustion chamber" which was simply a swedged nipple belled down. Before the air-gas mixture was introduced a lighted fuse was lowered through the orifice into a wire basket. This ignited the mixture when it was injected. The bottom hole temperature was raised to about 2300 F, and in one case as high as 3300 F. The obvious difficulty of fusion of the sand was probably offset by fracturing and caving of the hole at these extreme temperatures.

The Authors



D. V. Hester D. E. Menzie

Don V. Hester is a graduate assistant instructor at the University of Oklahoma. He received his BS degree in petroleum engineering from O. U. in 1951. At present he is working toward his masters degree and upon obtaining it will be employed by the Texas Company.

D. E. Menzie is an assistant professor of petroleum engineering at the University of Oklahoma. Prior to this time he taught at The Pennsylvania State University for two years and was employed for three years as a research assistant on a Pennsylvania Grade Crude Oil Association research project on secondary recovery of oil. He holds BS and MS degrees in petroleum engineering from The Pennsylvania State University and has completed additional advanced work from that institution.

In 1923 a patent titled "Process for Distilling Crude Oil Underground" was obtained by Frank A. Howard.[10] This patent was applied for in 1920 about the time of the real beginning of the burning process for removal of paraffin. Howard's process involved pumping air through the casing and gas through tubing into a cavity, which would be formed by shooting, in the injection well. An insulated cable would carry current from the top of the well to a resistance heating element for ignition at the bottom of the tubing.

Howard proposed that the heat generated by the burner and subsequent combustion of oil around the well bore would convert nearly all the oil to gas which would be carried with the flue gas to the surrounding producing wells or condense into oil in the cooler sand in front of the combustion zone and be pumped out as a liquid. Although no reference is made by Howard to a field test to support these proposals, they form the basis for much of today's research and field tests on sub-surface combustion drive.

In 1928 Lindsly[13] proposed the injection of hot gases to obtain recovery from oil sands depleted by primary production. The gases would be heated by combustion of gas or oil and air at the bottom of the injection well or shaft. According to Lindsly's calculations it would be necessary to pump 19,000,000 standard cubic feet of air and gas into each foot of pay sand per day. He suggested that the temperature of the reservoir should be raised to 700 F.

In order to inject the enormous amount of air and gas required he proposed sinking a mine shaft to the oil sand and driving galleries at least 50 ft horizontally into the oil sand. Although Lindsly figured a profit by the method on paper, no field tests made on it are known to the writers. The costs of such a project would be very high.

The use of dry steam to obtain increased recovery from depleted oil sands was reported by Stovall[24] in 1934. The field test described in his paper was preceded by a test run using a small drum 9 in. in diameter by 18 in. long filled with sand which was saturated with oil. In this test the dry steam was injected at the top and

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progressed to about 1 in. of the bottom of the drum before it broke through the producing outlet at the bottom.

Even in this small scale test the oil did not noticeably change temperature until the break-through. This would indicate that a bank of hot water consisting mostly of condensed steam pushed an oil bank ahead of it. The heating of the oil at the oil-water interface would cause a very favorable reduction in oil viscosity.

The field test described by Stovall was made on 150 ft spacing, injection well to producing well. Although the results of this field test showed considerable promise, the expense of heating the complete reservoir with steam was too great to encourage further operations employing this method as long as oil is in its present price range. The cost of natural gas used as the heating source can not be overlooked in this day of an increasingly large market for natural gas. Also, the close spacing required by this method increases the cost of such an operation. At the present time there is some research being done on dry steam injection.

In April, 1935, a group of Russian engineers[19] reported field experiments on sub-surface combustion drive. Laboratory experiments were run in the Grozny Petroleum Research Institute in 1933 and 1935 which indicated that combustion, generating high temperatures, can be maintained in sands containing residual oil by the injection of air through wells. Charcoal was used to ignite the oil. After combustion had progressed through the oil sand, the sand was found to be completely devoid of oil.

The first field test was performed in a very shallow sand that was oil-bearing farther down the structure. Four wells 16½ to 19½ ft deep were drilled at the corners of a 16½ square. Air permeability was established between the bore holes. Oil had to be introduced to the sand through the injection well as it was not oil-bearing at the experimental site.

The oil in the injection well was ignited, presumably by charcoal, and combustion was maintained by pumping air at low pressure into the injection well. Water vapor and gases escaped in increasing amounts from the other 3 wells, and pressure increased considerably.

The tests were then carried to part of the Shirvanui field of the Maineft where 3 wells 320 to 332 ft deep were hand dug. The sand had been completely depleted by current methods. Wells had been 16 to 20 ft apart and vacuum had been pulled on the sand. The distance from well No. 1 to well No. 2 was 19.7 ft, and from well No. 2 to Well No. 3 was 49.2 ft. Well No. 1

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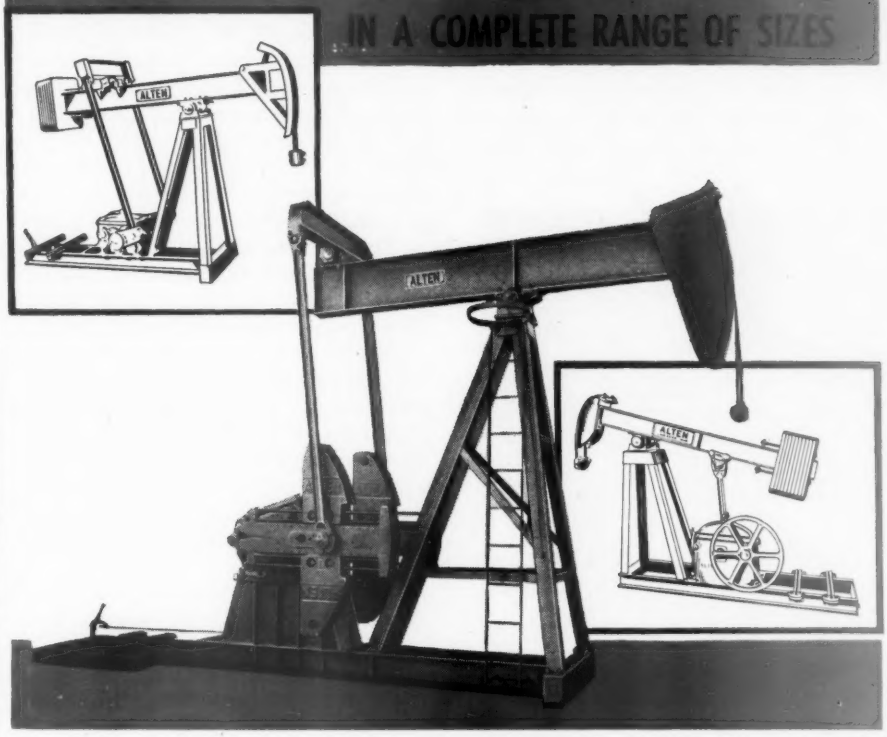

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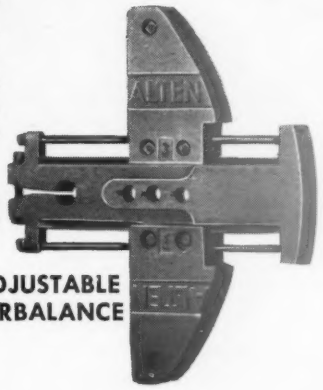

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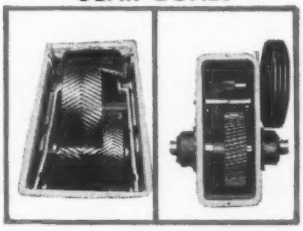

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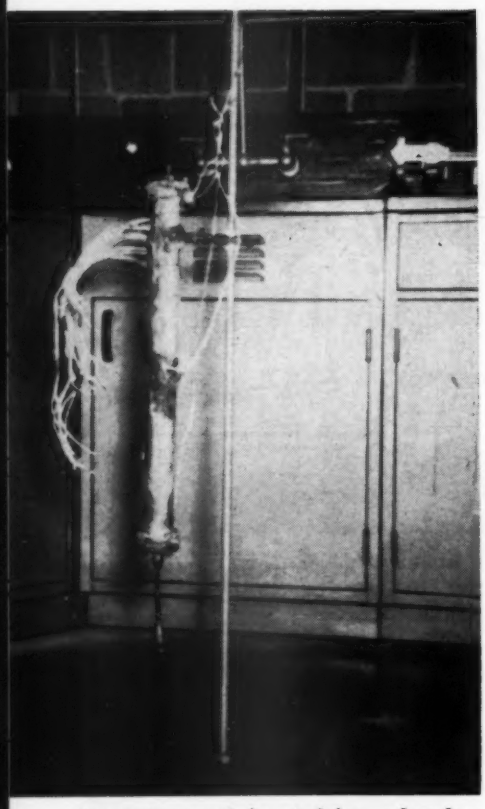
was used as the ignition well at the beginning. Combustion was started with charcoal and air was pumped into the ignition well to initiate and maintain combustion. Some oil and rich gas were produced from well No. 2.

In later tests supplementary oil was introduced periodically from the surface into the ignition well to start combustion, and charcoal alone would not ignite the low content of oil in the sands. Hot gases were also used as a means of igniting the residual oil. Gases were heated to about 500 C by a furnace at the surface and pumped into well No. 2. Oil or charcoal ignited by the hot gases were used actually to



Apparatus used in studying subsurface combusion process.

begin combustion at the producing formation in some cases.

The authors concluded that oil depleted sands could be ignited and combustion maintained away from the well bore. They also concluded that this combustion caused oil and gas to flow to producing wells where the oil could be pumped to the surface.

Frederick E. Frey[4] applied for a patent March 3, 1941, on a method contemplating "the inception and maintenance of flameless combustion within a hydrocarbon-bearing formation for the purpose of developing temperatures of sufficient magnitude to effect distillation and/or cracking of carbonaceous material and to drive thermally volatilized portions of the material from a thermally treated region to another location whence it can be readily produced to the surface of the ground."

Frey proposed the ignition of spontaneous combustion in the temperature range of 200 F to 600 F by flowing gases containing carbon monoxide and free oxygen through a catalyst such as hopcalite, which would be located at the depth of the oil sand. The catalyst would cause the free oxygen to combine with carbon monoxide, thus producing sufficient heat to commence the spontaneous combustion of the oil in the sand. He claimed that the application of a flame to the bottom of the injection well bore might greatly reduce the permeability of the oil sand immediately surrounding the well bore by fusion of the sand.

Frey claimed that the temperature in the formation could then be maintained between 350 F and 600 F by regulation of the injected air or other gas containing free oxygen. He claimed that the high temperature zone would spread from the injection well as the flameless combustion progressed, causing lighter fractions to be distilled off, some heavier fractions to be cracked and the "melting and flow of solidified waxy deposits."

Frey's patent was a theoretical patent with no supporting laboratory or field data presented.

Frey's method was patented June, 1945. In December, 1945, Barton and Dougherty[1] also patented a method of recovery by subsurface combustion.

Highsmith[8] wrote a thesis on "Flameless Combustion of Hydrocarbons in Porous Media" in 1948. His work largely consisted of lacing naphtha in a sand-packed reactor tube and running heated air into the tube. Both dynamic and static runs were made. This work indicated that a higher percentage of the oxygen content of the injected air was converted to carbon dioxide at low air injection rates than was converted at higher injection rates.

Although he did not mention it, there was necessarily a lower limit of rate of injection for this to be true. This lower limit would be reached when the per cent of carbon monoxide begins to notably increase, signifying an insufficient supply of oxygen. Also, Highsmith verified the fact that higher temperatures and/or higher pressures favor the rate of conversion to carbon dioxide at a given injection rate. In general, the data did not follow the curves drawn as well as might be desired.

Linden[12] mentioned an electro-thermal process called the Ljungstrom method in an article on "Sweden's Shale Oil Industry" published September, 1949. In this method oil was vaporized in the oil shale by heating the shale in place with electric heaters. The electric heaters were placed in bore holes which formed a hexagonal pattern 7 ft on each side. A "production well" was in the center of each hexagon. The oil vapors traveled to the hole by means of "a slight pressure in the strata." A production of about 126,000 bbl of oil and about 20,000,000 cu m of gas were produced in a year by the application of 14,000 kw, Linden stated. The electrical energy used per barrel of oil with its proportionate gas was approximately 973 kw hr.

Winkler[25] discussed application of heat to wells producing 75,000 cp viscosity (at 20 C) and 12.9 deg API oil from the Leoprechting field in Austria in 1951. In this case heat was applied through the tubing to the formation by steam, which upon condensing formed an emulsion with the oil. This emulsion was much easier to produce than the oil alone. Electric bottom hole heaters were also used. The principal effect of heat in the reservoir was that of reducing the oil viscosity in the critical area of relatively high flow rates in the formation immediately around the bore hole.

Squires and Merriam[23] suggested in 1952 a rather unique method of applying heat to oil reservoirs which overlay coal deposits. They proposed that two wells be drilled through the fire clay underlying most coal beds, and cased and cemented to the top of the fire clay.

The fire clay could be washed out around the well bores by pumping water through tubing to the fire clay where it could be jetted out the sides of the rotating tubing, wash clay particles loose and carry them to the surface through the annulus between the casing and tubing. The next step would be to apply sufficient water pressure on one of the wells to lift the overburden above the fire clay and allow water to flow from the high pressure well to the other well where it would return to the surface carrying clay particles with it, go to a settling pit and from there be pumped into the injection well. After the bottom of the coal bed is exposed sufficiently with this water wash, the water would be driven out by air. Squires and Merriam demonstrated this method of clay removal with a laboratory model.

Squires and Merriam proposed that a fire maintained by air injected at one well could be started in the coal at the bottom of the well. They maintained that there would be sufficient permeability through the coal for hot vapors and combustion products to escape into the permeable oil sand overlying the coal, gasifying all or part of the oil in

place. The gases and gasified oil would pass to the producing well and through it to the surface.

A modified system was suggested where the coal was separated from the oil sand by an impermeable layer such as shale and was either permeable or made permeable by the fire clay washing method mentioned above. The coal would be burned as before and the gases coming from and through the burning coal would flow into the second well where they would pass by a burner. Air would be injected through the burner from the surface of the second well to maintain combustion of these producer gases. The burning gases and combustion products then would pass into the oil sand and cause gasification of some of the oil and viscosity reduction of the remaining liquid oil by heating the reservoir.

The gasified petroleum, other gases, and liquid oil in this modified case would be produced through the annulus between the casing and tubing of the first (injection) well. Although there appear to be many unsolved problems between the theory and the field application of this method, it may prove to be of value in certain fields.

Squires and Merriam[22] later wrote an article proposing better use of the latent heat of steam to heat the reservoir. By keeping the burner in the injection well immersed in steam and the temperature of the reservoir low enough to condense the steam the heat of vaporization of the steam would be given up in the reservoir.

Squires and Merriam described a burner designed for this type of operation. Air and gas were fed to the burner in combustible mixtures through small pipe at velocities in excess of the velocity of flame propagation. The mixture was ignited in a combustion chamber with a spark plug and coil assembly operated and powered from the surface. The air-gas mixture was passed through catalytic dice, such as a porous kaolin brick, which were in a conical container at the entrance to the combustion chamber.

The velocity of the explosive mixture varied from very high at the small end of the cone to very low at the large end. This allowed the burn-back rate of the air-gas mixture to find its matching input velocity at some point in the cone. This burner was tested at shallow depths in the field and was found to operate satisfactorily, though the complete process of using steam has not been field tested to the writers' knowledge.

Slezak and Davis[20] made some theoretical proposals and mathematical calculations on pyrovolatilization as applied to the Bradford Third sand in 1952. They proposed to apply the ideas

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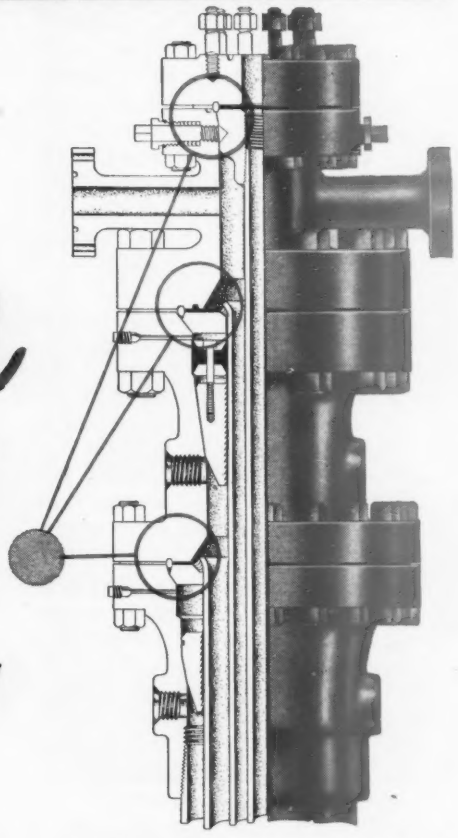

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from the Ljungstrom process[12] and later research work which had proven that rocks could be fractured with high voltage electricity and, after break-through, could be heated with electricity sufficiently to vaporize any hydrocarbons present in the sample.

They proposed to bring oil to its ignition temperature by electrical break-through between wells and force compressed air into the reservoir to begin and maintain combustion of the oil. Combustion would occur mostly near the fractures caused by electrical break-through. This combustion would further heat the oil and gasify some of it.

Slezak and Davis made some calculations to estimate the energy required, per cent of oil produced, air requirements and overall economics of the process as it would be applied to the Bradford Third sand. They acknowledged in their conclusions that a field test is the "only way to truly evaluate a process such as pyrovolatization."

Hill[9] concluded from his laboratory results that sands with little or no organic material were not receptive to dielectric breakdown and that beds having a high organic content (such as shales) appear to be more easily broken down. This would establish certain limits on the pyrovolatization process discussed by Slezak and Davis.[20]

Smith and Watson[21] obtained a patent on June 23, 1953, on an oil recovery process involving propogation of a heat wave by combustion in the reservoir. This patent was applied for May 20, 1949, and was assigned to Sinclair Oil and Gas Company. It represents one of the more modern and complete approches to the problem of obtaining additional oil from the reservoir by the application of heat. Smith and Watson found that a minimum temperature of about 700 F was necessary to recover oil in substantial amounts over that recovered by well-known secondary recovery methods.

This method involved heating the oil-bearing sand around the injection well with a bottom-hole burner, preferably from 1000 F to 2000 F. When the desired temperature had been reached, cold gases containing about 1.33 to 6.0 per cent oxygen were injected into the formation. These gases were heated by the hot formation and carried the heat to and in front of the combustion zone which was coincident with the front of the heated zone or just slightly behind it. Thus, the gases caused the horizontal movement of a heated wave to move outward from the injection well into the formation.

The combustion of coke, which remained when all the rest of the oil had been vaporized, cracked, or driven ahead by the hot gases at the leading edge of the heat wave, maintained or built up the high temperature in the heat wave. Control of the oxygen content of injection gases could be made by constant regulation or by periodically interrupting the oxygen supply. This regulation of oxygen content would provide control of the rate of advance of the combustion zone.

Smith and Watson stated that the combustion zone should be just behind the leading edge of the heat wave. If the combustion zone advanced so fast that it got ahead of the heated zone, they contended combustion would die out due to low temperatures.

They found that clays contained a large part of the oil and water in "exhausted" oil sands and suggested that the main function of the elevated temperatures might be to break up an adsorption complex in this clay.

In fiields of high gravity crude and good permeability fuel gas would be intermittently introduced along with the oxygen-containing gas. This gas would pass through the cooled zone behind the heat wave and ignite in the heat wave.

Several laboratory tests were run by Smith and Watson before the patent was applied for. They consisted of burning out a 4-in. tube packed with oil, some coke, and sand, burning from an injection "well" to a producing "well" in a reinforced sheet metal box 31-in. by 43-in. by 24-in. packed in a similar manner, and burning ground core samples from the Nowata field which were sealed in quartz. One conclusion reached from these tests was that temperatures in excess of 450 F to 500 F were necessary for sustained combustion, but 600 F to 1000 F was a more desirable temperature range for recovery of oil.

A further example cited in the patent consisted of the theoretical application of the method to the Delaware-Childers field of Nowata County, Oklahoma. A paper giving some field results of this method was published later.[5]

Kuhn and Koch[11] reported on work done by Magnolia Petroleum Company on "in-situ" combustion August 10, 1953. Tubes packed with low gravity oil and sand and electrically ignited were successfully burned with air in the laboratory. Less than 15 per cent by weight of the oil remaining after air drive was found to be lost by combustion. The flame front was easily traced in the tube by the use of thermocouples. The peak temperature with 9.6 deg API gravity oil and an injection rate of 324 standard cubic feet per hour was about 1600 F.

The laboratory tests confirmed that four zones existed in the sand during combustion. These were the clean burned sand, the combustion zone, coked sand, and partially liquid-desaturated oil sand. Kuhn and Koch interpreted that the coke remaining after vaporization, displacement, or cracking of original hydrocarbon liqiud and gas furnishes the bulk of fuel consumed by combustion.

Temperature records frequently indicated steam plateaus, which were considered to be the result of condensation of water vapor in the cooler zone ahead of the combustion zone. Oil recoveries of from 60 to 90 per cent of oil remaining after air drives were obtained.

Field tests by Magnolia Petroleum Company were run on a shallow field in southern Oklahoma. The oil in the sand had a viscosity of 7413 cp and was 18.5 deg API gravity at 60 F.

Three wells drilled in line were used for the test. The center well was 20 ft from the well on either side of it. Sufficient air permeability was established between the two extreme wells by injecting air from one to the other. The oil and sand were raised to ignition temperature in the injection well with an electrical resistance-type heater while air was being injected. Combustion was indicated by the production of carbon dioxide from the production well. Eighty-one barrels of oil were produced by the central in-situ combustion well.

One of the test wells had produced less than 20 bbl over the same period before the in-situ combustion test was began. It was estimated by mass balance that 9½ bbl of oil were burned by combustion in the reservoir. The combustion zone progressed to the first production well, 20 ft distant, in 55 days. Coring revealed that the burned out zone extended as much as 10 ft horizontally on either side of a line from injection well to producing well.

Some difficulty in maintaining combustion was experienced. This was believed to be due to banking of liquid around the injection well bore. A five spot test which has now been started is expected to shed further light on this problem.

A progress report of this five-spot test, along with some photographs of the surface installations, is included in a report written March 4, 1954, by Saxon.[18]

Breston and Pearman[3] developed a bottom hole heater designed to heat injection water in a waterflood. The primary purpose of this method was to increase water injection rates. The type of heater used possibly could be modified to use for igniting the oil sand for underground combustion. Basically the heater consists of nichrome wire insulated with ceramic beads.

A report on the operations of Sin-

clair's field tests of recovery by a combustion-supported heat wave was given by Grant and Szaz[5] in February, 1954. The burner, which was especially designed for this work, was tested in the field. After the burner successfully ignited the oil sand, the test was continued to determine limiting amounts of air, recycle gas, or fuel gas. The expected dependence of heat wave propagation on oxygen-fuel rates of injected gases was confirmed.

In this particular test it was found that a mixture containing 80 Btu per cubic foot and 6 per cent oxygen produced the highest rate of movement of the combustion zone. When the air fuel ratio reached the explosive range, the combustion backed up to the injection well.

Subsequent to these preliminary tests, the method was tested on an inverted 7-spot pattern with an average distance of 300 ft between producing well and injection well. The first injection well became plugged due to caving which followed ignition of the oil sand during several attempts to maintain combustion. A second injection well was drilled 6 ft from the original injection well. Thirty days after ignition was accomplished in this well an explosion occurred in it and the well was abandoned. This explosion followed a switch from an injected mixture containing produced gas and 6 per cent oxygen to one containing produced gas and 12 per cent oxygen.

One of the core holes, which was 26½ ft from the original injection well and which had been used as an observation well, was prepared for injection. Ignition and propagation of a combustion zone was successfully made from the well. The results of this test were encouraging. Coring indicated that practically all hydrocarbons were removed from the heated zone. The sequence of recovery as the combustion zone approached a producing well was as follows: "(1) a tight emulsion . . . (2) . . . 45 deg API distillate, (3) . . . a mixture of water and colloidal iron oxide having the appearance of thin red barn paint, and finally (4) a five-fold increase in gas production rate and the production of clear water with a trace of black residual oil . . ."

A section of the Delaware-Childers field in Nowata County, Oklahoma, was the test site for the above test. Production was from the Bartlesville sand at depth of about 600 ft. The oil gravity was 35-37 deg API. This section of the field was developed in 1912 and in 1934 gas injection was started on it.

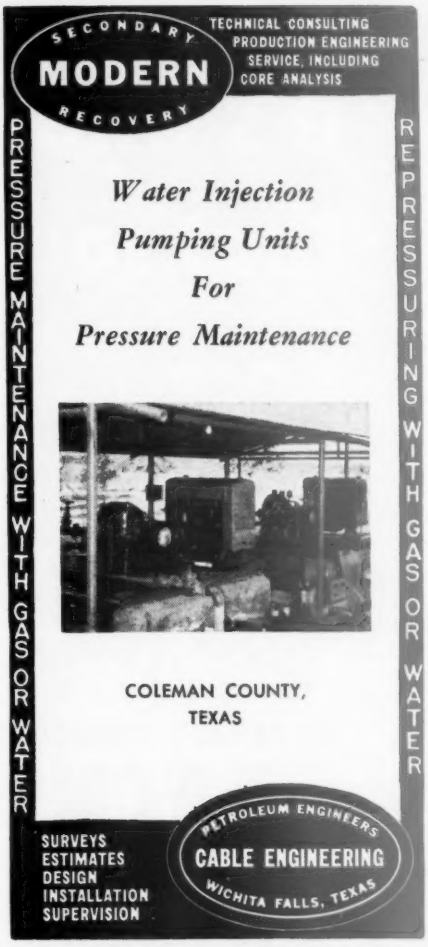
Ramey and Nabor[16] reported a method of determination of areal sweeps in oil recovery by in-situ combustion with a blotter type electric model in February, 1954. The problem of representing a very high mobility to gas behind the combustion front as compared with a much lower mobility to gas ahead of the combustion front had to be overcome. As the mobility ratio behind the front was considered infinite, the area representing the burned out area was painted with conducive silver paint as it progressed across the blotter.

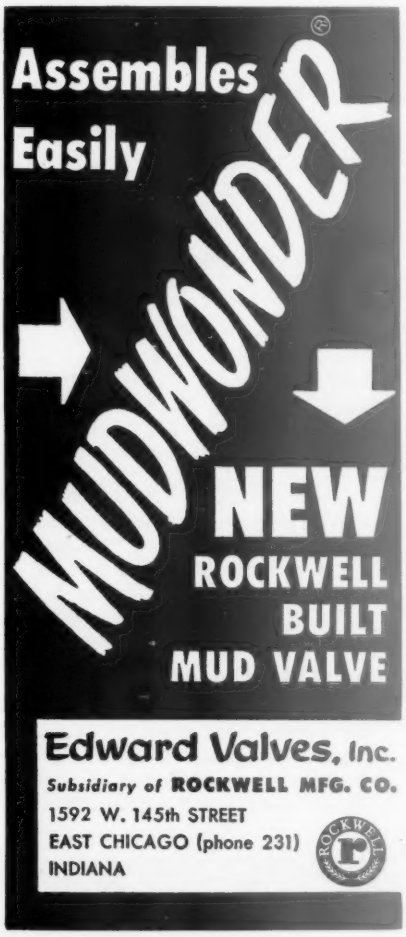
Results of blotter tests for a modified two-spot pattern with a mobility ratio of 1 indicated a sweep-out efficiency of 46.1 per cent. The same test run with infinite mobility ratio indicated a sweep-out efficiency of only 20 per cent. Ramey and Nabor recognized that this was a highly idealized attack on a complex problem, but the rapidity and ease with which these tests can be made could make them a very useful tool. Comparison with future field tests will be necessary before results obtained can be properly evaluated.

Heat transfer is a very important problem when making predictions on reservoir when any type of heat is applied. Some studies which are relevant to the problems involved are those by Harbert, Cain, and Huntington,[7] by Greenstein and Preston,[6] and by Preston and Hazen.[15]

Cain et al studied unsteady and steady flow of heat into a sand-packed cylinder with (1) air in the pores and (2) water in the pores.

Greenstein and Preston studied heat gain by unconsolidated sands during hot water injection. Preston and Hazen wrote an article which was a follow-up





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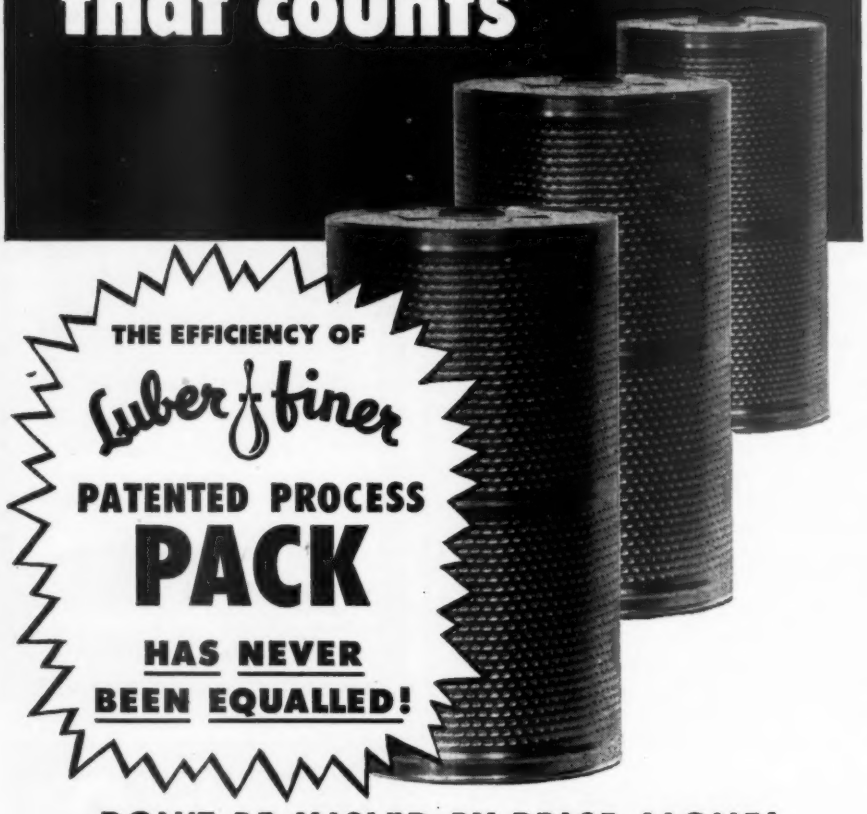

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of the work by Greenstein and Preston. Some useful equations were developed by them. These equations may have some application in modified form in calculations regarding subsurface combustion in the reservoir.

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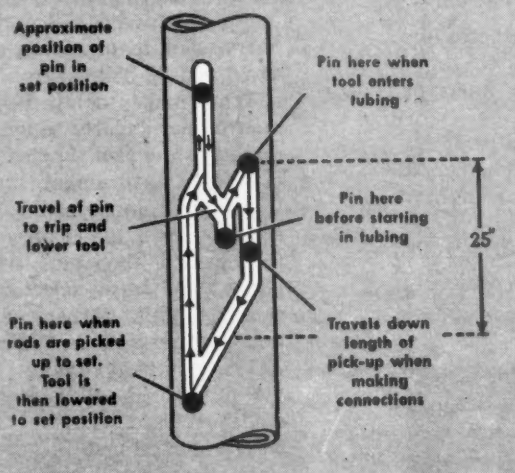
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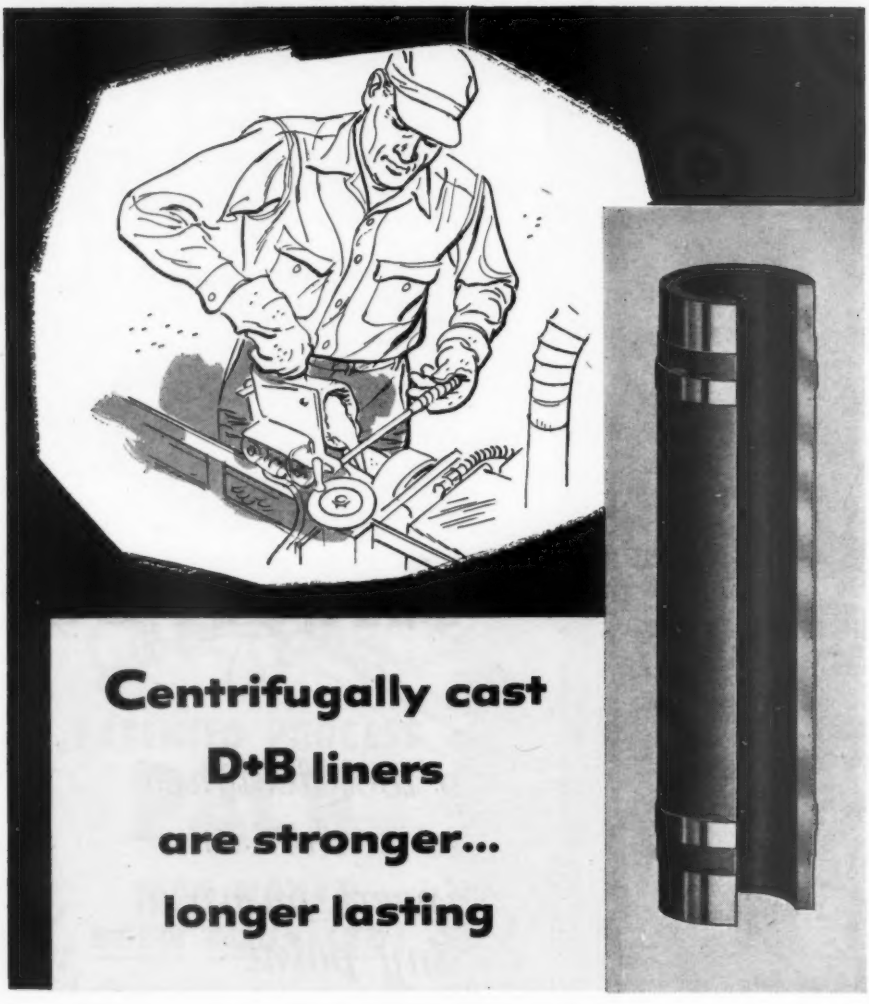

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E-171

Alberta Plans for Biggest Winter Operations

ALBERTA'S oil industry is gearing up for its biggest winter operation in the history of oil-search in this western province.

The coming months will see drilling rigs shuffled around from one oil area to another at a rate never before associated with the season, and on a scale that will surpass normal busy summer operations.

It is not a situation enjoyed by the industry, but is one resulting from five wet summer months that placed an almost constant curb on oil field operations and, many times, brought activity to a complete standstill.

Alberta has had wet summers before. What made this one particularly tough was the fact oil men were working in new oil fields such as Pembina and Sturgeon Lake—areas far off hard-surfaced highways, covered with heavy bush and dotted with muskegs. Even a dry summer would have presented problems.

By the end of July, the total footage drilled this year in Alberta was 3,000,000 ft, down from 3,500,000 at the same time last year. A total of 370 new oil producers have been found compared to 517 at the period a year ago.

The number of rigs operating in the early summer was only 97 compared to 132 a year ago and 138 in January.

July saw only 170,000 ft of wildcat drilling as compared to 187,000 drilled in March when the ground was frozen. At the present time there are only 78 seismic crews operating in the province compared to the 178 crews last February when temperatures often slipped to 20 and 30 below zero.

What makes delays beyond human control particularly tough on the operators is the fact they still must comply with government regulations in meeting development deadlines. When a discovery is made on a reservation, the operator then must make what is termed a "lease selection"—50 per cent of the total acreage of the reservation—within a 90-day period.

The company cannot drill within 4½ miles of the discovery until it has made its lease selection with the Department of Mines.

The large proportion of the big operations anticipated for this winter undoubtedly will be in Pembina. Most of the drilling rigs are capable of handling the 5 to 6000-ft drilling of the Pembina field, whereas winter operations at the Sturgeon Lake field will increase. They will be limited somewhat by the fact only 15 per cent of the rigs can tackle the 9000-ft drilling.

Oilmen expect upwards of 400 wells to be drilled in Pembina this winter.

DRILL PIPE AND DRILL COLLARS

Fritz W. Schall*

NOT too many years ago, steel was "iron" to the oilfield and it either "held together" or failed. Alloy steels came to be recognized gradually as materials for giving strength, hardness, or durability to oil tools.

The first drill pipe was a low carbon butt-welded or lap-welded pipe with short couplings of similar material. Failures soon proved such a pipe unsatisfactory for deeper drilling and the hot-rolled and pierced seamless tube was introduced made of higher carbon, higher tensile strength steel. Because of the necessity of continually making-up and breaking-out the joints, it soon became apparent that the short fine thread couplings could neither stand hard usage nor be made-up and broken-out fast enough. In 1910 the first heavy section tool joints were introduced. In 1912 tool joints were made of alloy steel and in 1925 these were adopted as standard by American Petroleum Institute.

The pipe, although an improvement, proved to be weak at the threaded sections on the ends. In an effort to eliminate this weakness, the pipe was upset on the ends as much as two and one-half times the thickness of the body of the pipe to compensate for the material removed in threading.

Since that time there has been continual progress to offer better, more durable drill pipe to the industry until today we have available various grades of pipe giving us a selection of physical properties such as collapse resistance, tensile strength for longitudinal loading or depth, and bursting or internal yield pressure.

Selection of a string of drill stem with respect to its physical properties, must be determined by the individual as to what type of work this pipe will be subjected and to any possible subsurface conditions it will encounter. This information is available in any tubular products handbook.

Also due to progress through the years, we have at our option various types of tool joint attachments of which there are many variations but three basic types are available, i.e.:

(a) Integral;
(b) Welded-on or Unitized tool joints; and
(c) Threaded pipe end connections.

Selection of the type connectors used will depend upon field conditions, services available, and special problems that will be encountered.

Size or type of tool joint along with the size and weight of drill pipe that is to be selected will be dependent upon the following conditions:

(1) The amount of clearance desired for fishing and wash-over, which will vary with areas;

(2) The internal diameter of the tool joint that will allow sufficient clearance for wire-line coring or internal cutting tools; and

(3) The hydraulic factor.

In the past, more attention has been given to clearance and tool joint types than has been given to hydraulic factors. As wells become deeper, and longer strings or drill collars are being used for weight on the bit, the hydraulic factor becomes more important, because more horsepower is consumed in overcoming drill stem losses.

If the new technique known as "jet drilling" is to be effectively utilized, more attention must be given to hydraulic efficiency of the circulating system. At present, we know that nozzle velocities to be effective must be above 250 ft per second. If large quantities of horsepower or energy is being uselessly wasted circulating through a poorly designed circulating system, it becomes a problem to provide enough power to produce the high nozzle velocities desired in jet drilling.

Each area may have individual problems that necessitate a separate study of what can be done or what is desired to give the most advantageous results. For example, areas such as West Texas have a handicap in that long strings of small bore drill collars must be used, which in many instances account for approximately one-third of the pressure losses, whereas other areas such as the Gulf Coast are working under the handicap of heavy weighted muds which causes pressure losses to increase appreciably.

The slowness of improvement until recent years in the hydraulics of drill stem is due to a general lack of attention to the importance of relatively small differences in the internal diameters of drill pipe and drill collars which conduct the flow of fluid.

In selecting any portion of the drilling string, how much thought is given to the differences between a 2-in. bore and a 2¼-in. bore? It is only ¼-in., but if the need requires the use of 20 such collars for weight, and the circulating requirements are 350 gal per minute, it means that losses through the drill collar string are nearly doubled, yet the weight increase of an average 6¼-in. OD drill collar string is increased only 3 per cent by using the smaller bore.

To approximate the importance of internal diameters, consider that it takes approximately 30 times as much power to circulate through a 2-in. ID pipe as through a 4-in. ID pipe. In terms of drill pipe this means:

(1) Approximately 7 times as much power is required to circulate through a 2-in. bore collar as through a 3-in. bore collar at the same circulating rate.

(2) Approximately 2½ times as much power is required to circulate through a 3½-in. OD drill pipe as through 4-in. OD drill pipe at the same circulating rate.

(3) Approximately 5 times as much power is required to circulate through a 3½-in. OD drill pipe as through 4½-in. OD drill pipe at the same circulating rate.

(4) Approximately 3 times as much power is required to circulate through a 4½-in. OD drill pipe as through 5½-in. OD drill pipe at the same circulating rate.

All of the above information can readily be obtained from hydraulic books that are available to the industry. It is also surprising to note the differences that can be attained by the section of the tool joints to accompany the various sizes of drill pipe.

In summing up the "Hydraulic Factor," too much emphasis can not be placed upon hydraulic efficiencies, as these losses have a significant bearing in terms of equipment, maintenance, and fuel costs. Each individual must analyze his individual problem and arrive at the selection that will benefit him the most.

Maintenance of Drilling Strings and Tool Joints

Life of a drilling string is more or less governed by the area in which it must operate. The method most frequently

*Drilling Engineer, Production Division, Magnolia Petroleum Company.

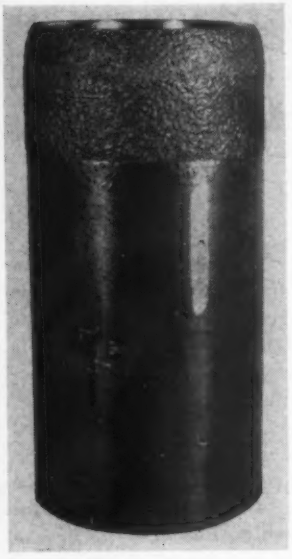

FIG. 1. Eccentric wear resulting from crooked pipe is one of the most common causes of premature tool joint wear.

used to evaluate the life of a string of drill pipe by the footage it has made is of little value when comparing life of drill pipe with respect to areas. Rather than a straight footage evaluation, a more accurate evaluation can be attained by evaluating life of drill pipe in terms of rotating hours.

Life of drill pipe or tool joints is governed by two basic factors, i.e., OD wear and premature failures caused by corrosion fatigue. Although wear on the outer surfaces of drill pipe and tool joints has occurred since the earliest days of rotary drilling, advances in operating practices and design have so greatly increased drill stem life, that OD wear has become a major problem.

In the early days, most of the drill stem was operated in compression because holes were shallow and because only one drill collar was used. This caused the drill pipe to "spiral" in the hole and contact the wall with considerable force. Under these conditions wear on the drill pipe was almost as great as on the tool joints, and on the thin wall sections of the pipe caused failures to occur in the pipe before excessive damage had been done to the tool joint.

At present, almost all drill stem is operated in tension, holes are becoming deeper and drill collars are used to provide weight needed for drilling. Operating in tension increases pipe life, not only because of reduced wall wear, but also fatigue failures decrease. With the advent of this change in drilling practices, tool joints must withstand wall wear for a much longer time if they are to last as long as the pipe.

OD wear may take several forms, depending on operating conditions, and on formations drilled. Greatest wear occurs where formations are abrasive and not unusually hard and where few drill collars are used. Less wear occurs where formations are not abrasive and where sufficient drill collars are used to keep all of the drill pipe in tension.

The softer, abrasive formations cause tool joints to become "barrel shaped." It is commonly thought that this is because in soft formations, the tool joints can penetrate the walls of the hole and as drilling progresses, tend to ream down.

Often tool joints wear eccentrically or "lop-sided." In most cases wear of this type can be traced to the use of crooked drill pipe. Certain unknown factors may produce critical rotating speeds at which a centrifugal "throw" causes the same side of the tool joint to continuously rub the walls of the hole.

To overcome or combat OD wear, the following steps can be taken to avoid the high cost of scrapping drill pipe or the expensive cost of remedial or repair work:

(1) **Oversize Tool Joints.** Where the size of the hole does not limit their use, it is generally good economic practice to use oversize tool joints. The cost is small and the results very noticeable.

(2) **Keeping Pipe Straight.** The eccentric wear which occurs as a result of crooked pipe is one of the most common causes of premature tool joint wear.

(3) **Hard Facing Tool Joints.** (Fig. 1): The type of hard-facing deposit used on tool joints at least doubles the life of tool joints and in most cases this increase is sufficient to make the tool joint last as long as the pipe. Hard banding can be applied to the tool joint at the time of purchase or can be used to check wear. Field facilities are available to apply hard banding in the field to eliminate costly long hauls.

(4) **Sleeving of Tool Joints.** If the OD wear has gone unchecked, but the threads of the joint are still good, another method that is being used to return the OD of the tool joint to a safe workable size is a process known as "sleeving," in which the old joint is turned concentric to the body of the pipe and a sleeve is shrunk on and welded to the shoulder of the original tool joint.

(5) **The Field Replaceable Tool Joint.** Replaceable tool joints are mentioned, not because they resist wear, but because they are intended to facilitate the replacements which are necessary due to excessive OD wear.

The second limiting factor that determines the life of drill pipe is premature failures due to corrosion fatigue. This factor is more predominate in areas where salt or corrosive formations are encountered.

In its simplest form, corrosion fatigue may be considered as notch fatigue in which the stress-concentration point has been formed by a corrosion pit. The progress of fatigue is thus hastened by corrosion. Whenever steel is subjected to cyclic stress of sufficient magnitude, whether in tension, compression, torsion or bending, it will fail ultimately by fatigue fracture. The simplest illustration of bending fa-

FIG. 2. Spotty corrosion pitting inside uncoated drill pipe. There is one or more fatigue cracks in almost every pit.

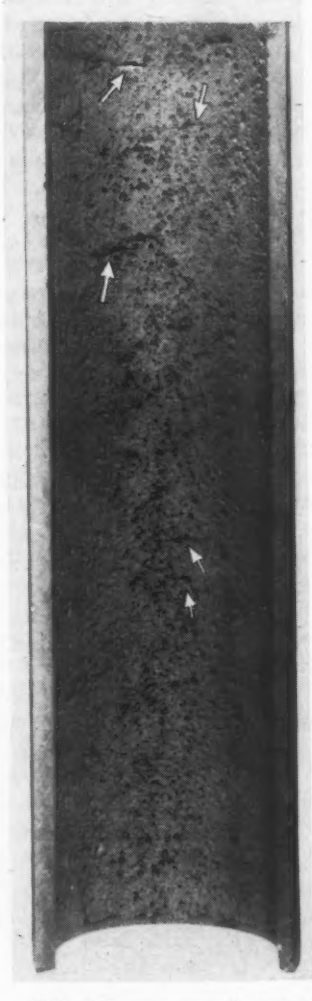

FIG. 3. Severe corrosion sometimes develops inside drill pipe with no protective coating. Arrows indicate cracks.

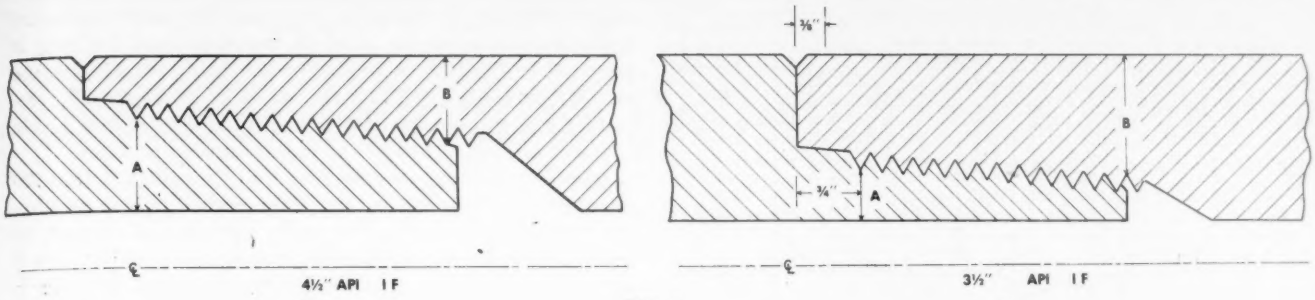

FIG. 4.

tigue is that of breaking a wire or nail by bending it back and forth several times. If a sharp traverse notch is placed in the nail, it will hasten the break. This is a reasonable conception of what happens when corrosion fatigue occurs in ordinary drill pipe.

It is an established fact that most corrosion fatigue failures of drill pipe start on the inside surface, as shown in Figs. 2 and 3. Perhaps this is because the corrosion process gets little opportunity to proceed on the outside due to the outside walls continually polishing by contact with the hole and due to the stream of formation cuttings pinging upon the outside walls of the pipe.

There are two basic protective measures taken for avoidance of and insurance against costly fishing jobs that may result from drill pipe failures, i.e., (1) use of protective methods to check corrosion, and (2) non-destructive inspection methods to weed out potential failures.

Protective methods can be broken down into two classifications: Coatings and Use of Inhibitors.

Protective Methods

Protective pipe coatings are of various types but can all be referred to as plastics. The pipe is first thoroughly cleaned of all mill scale by sand blasting, then the coatings are applied either by a spraying process or by a dipping process in which the thickness of the coating is only approximately 0.0015 of an inch.

The economics of such a venture has been very gratifying in that the cost of coating the pipe is only approximately 12 to 15 per cent of the investment, yet field results indicate life of the pipe can be more than doubled.

The other method used to combat the effect of corrosion fatigue is by the use of an inhibitor in the mud system. The inhibitor most often used is a chromate. It is necessary to maintain the concentration of 2000 to 3000 ppm, which calls for frequent checks by a mud chemist to assure proper concentration.

Non-Destructive Inspection Methods

This procedure does not combat corrosion fatigue but is worthy of mention in that it may reduce costly fishing jobs than can result from drill pipe failures.

There are various methods in use at the present time to evaluate the potential or remaining life of the drill pipe.

(1) Hydrostatic testing of drill pipe can be used in areas where there has been appreciable OD wear thereby reducing wall thickness.

(2) Magnetic inspections of which there are various types have their greatest value in finding cracks in the drill pipe.

(3) Physical testing methods where the pipe is bent or pulled to determine its remaining physical properties.

Drill Collars

Use of drill collars in rotary drilling strings has undergone a process of evolution by trial-and-error methods since early in the development of rotary drilling. Of particular signficance through the years has been the discovery that straight heavy-walled tubular sections just above the bit are beneficial in two ways. First, the rate of drill penetration is increased. Second, the number of drill-pipe failures is reduced.

Thus experience has led to the general practice of employing drill collars usually in multiple lengths and has resulted — again mainly by trial-and-error — in considerable refinement in the manufacture and technique of using them.

Selection, application, and proper field handling of drill collars undoubtedly contributes most to their satisfactory performance and the maximum service obtainable. The importance of good drill collars in a drill string can not be too highly stressed. Even though a drill collar appears to be a fairly simple piece of drilling equipment, it is necessary to expend a considerable amount of metallurgical engineering and mechanical design knowledge in order to produce a longer lasting collar.

Unlike drill pipe, a drill collar has extremely heavy walls to supply the necessary weight. As a result, it is quite rigid and major stress that results from any bending or whipping of the drill collar is concentrated at the threaded ends. In the case of drill pipe, on the other hand, the most rigid part of the drill string is the connections. Any flexing is easily taken in the central part of the drill pipe and stresses at the threaded connections remain relatively low.

To give an idea of the severity of the problem a study of the service given by a large number of drill collar connections indicated that under severe drilling conditions stresses at the thread roots will often closely approach the elastic limit of the steel used — and this stress is reversed at every revolution of the drill string.

Selection of Drill Collars

Selection of drill collars with respect to OD and bore have the same limitations that govern the selection of drill pipe, i.e., OD limited by safe wash-over and fishing clearances, and the bore is limited by clearances needed for wire line coring, and fishing tools available.

It has been a recent trend to use "oversize" drill collars for the purpose of maintaining straight holes. Each individual must make his own decision as to what factor is most desirable, sufficient wash-over clearance, or the use of a calculated risk for faster penetration rates in crooked hole areas.

Again the factor of hydraulics must not be overlooked. In areas where long strings of collars are used, the hydraulic factor is of even greater importance. As shown previously the difference of ¼ in. in the bore does not materially effect the weight but does greatly effect the hydraulic factor.

Once the OD and bore have been selected, the next step of great importance is selecting the proper joint. In recent years, much has been written about "balanced joints." A balanced joint is one in which the box and pin at the point of most frequent failure are of equal strengths. A joint that

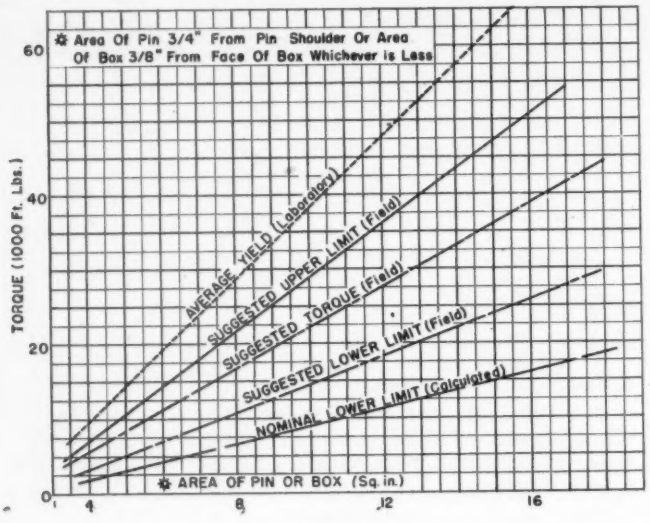

FIG. 5.

may have been a "balanced joint" at the time the collars are new, may not be a balanced joint a year or two years hence, due to reduction in OD by wear. The OD of the collar, in most instances, suffers the greater wear; consequently, the box may become weakened, resulting in box failures.

No matter how satisfactory the current API connections might be, if they are misapplied, the stress imposed will be more than the finest material can withstand. Fig. 4, A, illustrates the cross section of a 4½-in. API Internal-Flush connection applied to 6¼-in. diameter collar with 2¼-in. bore. B shows the same size collar with the 3½-in. API Internal-Flush type.

It seems obvious that the selection of these connections for the outside diameter and bore involved has resulted in one case in sacrificing the box section and in the other thinning the wall under the pin threads. While these might seem far-fetched as examples, in practice similiar unsound applications have been observed with such resultant grief to the operator. What happens, of course, is that the party responsible for the drill stem did not realize that the tool-joint connections of the pipe are not necessarily suitable for the collars.

Maintenance of Drill Collars

Various methods have been successfully used in the field to prolong the life of a drill collar joint and to reduce costly fishing jobs.

Practically all drill collar failures noted in the field are a result of fatigue at the connection, either simple fatigue as in the case of pins or corrosion fatigue in the cases of boxes.

The joint has had its life extended by two processes that have relieved stress concentrations, i.e.:

(1) Cold working of the thread roots that places the surface fibers in compression. This means that the fibers beneath the surface fibers are forced to take a greater share of the tensile load, thereby reducing the surface stresses to the value that results in their having a greater endurance life.

(2) The use of a "stress-relief groove" means that a round bottom groove was cut in the joint to a depth of approximately 3/16 in. below the thread roots at the region of the last engaged thread, which is a well known stress concentrating point. Use of the stress relief groove has been used satisfactorily on the last engaged threads of the box and the last engaged threads of the pin.

In areas that are subject to corrosion, it was believed that box failures were the result of corrosion fatigue. To prevent such failures, the obvious approach is to stop corrosion. The most recent development has been to use a magnesium ring in the drill collar box. By electrochemical action corrosion of the steel in the bore near the ring is prevented. The ring is located in intimate contact with the threads, at which the failures start. In offering such protection, the magnesium ring is consumed and is apparently effective so long as any of the metal remains in place.

Regardless of the engineering and thought put into the selection of drill collars for their metallurgical requirements, selection of balanced joints and uses of methods to overcome stress concentrations, it will be of little value if the drill collars are not treated properly in the field. Some excellent recommendations, which will greatly lengthen the life of tool joints are available, written by R. S. Grant and H. G. Texter, entitled "Causes and Prevention of Drill Pipe and Tool Joint Troubles."

Near perfection in manufacturing permits little tolerance for the failure of properly maintained drill collars. Factors contributing to drill collar failure include excessive rotary speeds, overtonging, corrosion fatigue, and loose joints.

The torque tonging of drill collars remains in an experimental stage because of so many variables, such as the type lubricant employed, condition of the threads, and friction factors. Manufacturers have done considerable work on the problem, however, and in the process have developed tentative torque values (Fig. 5). Field application of the tong torque indicator will permit a greater expansion of these data. If the joints show any indication of running loose, or the threads being distorted, the actual torque value that gives the optimum results can be determined for the size collar and the type joint in use.

An inspection of data shown in Fig. 5 indicates the upper and lower torque limits. Derived from laboratory and field experimental investigation, the upper limit represents torque factors which will induce failures. In turn, the lower limit torque value theoretically insures closed drill collar shoulders. Between these two limits are three additional curves covering the safe operating range with the "Suggested Field Torque" curve as the optimum range.

The suggested torque values are a relationship of the cross-sectional area of the box or pin, whichever is the smaller. The cross-sectional area of the box is determined by calipering at a point ⅜ in. from the face of the shoulder as shown in Fig. 4, B. This area will vary with the outside diameter of the drill collar if identical joints are used. The cross-sectional area of the pin is determined at a point ¾ in. from the shoulder of the pin. Of course, this area on identical joints will vary in proportion to the bore of the drill collar.

In areas where long strings of drill collars are used, excessive stresses cause frequent breakage or extreme wear on pins and boxes. In either case, the collar must be sent to a machine shop to have pin and box threads recut. Several of these trips to a shop will shorten the collar to where it is very difficult to use in drilling. As a result, rather than discard the collar, machine shops have devised various methods of adding to the length of the collar — a process known as "stubbing."

One of these processes involves adding a short section of new collar onto either or both ends of the old one by means of welding. This process has been in use for approximately 3 years, and a collar can be returned to its full length, with sufficient OD to have a balanced joint, for approximately 25 to 30 per cent of the cost of a new drill collar.

Selection of any portion of the drilling string should be made after a thorough investigation of the problem involved and conditions that will be encountered.

After the proper string has been selected, it is the problem of the man in the field to utilize this string to its utmost by adopting known procedures and practices that will prolong the life of this string. * * *

MASTS, DERRICKS AND SUBSTRUCTURES

James Moon*

DESPITE the fact that most of the steel associated with an oil well is below the ground the oil derrick is the symbol by which an oil well is known. To many people it is the trademark of the oil industry — in fact they often give little thought to what is going on below the surface of the ground, seeing only that which is above.

The oil derrick, however, has just undergone an extensive period of transition. In the majority of cases the permanent derrick is a thing of the past. Conventional derricks are still used but are seldom left up over the hole. Some manufacturers have actually discontinued production of conventional derricks as the market is pretty well absorbed by a large inventory of conventional derricks left over the hole in times past. Also there are derrick construction contractors with a large supply of conventional derricks which they rent for drilling purposes.

Derricks in use in the oilfields today fall into three broad classifications; conventional, portable skid types (usually free standing), and portable mobile types. All can be used for drilling and servicing but today the first two types are predominantly used for drilling and the last type for both drilling and servicing.

Conventional Derricks

Considering the conventional derrick first, the reader is referred to API Standards No. 4A API Specifications for Steel Derricks (including standard rigs) and to Fig. 1 which shows proper derrick nomenclature.

There are 9 API sizes of conventional derricks. These have the following general dimensions:

Derrick size no.	Height A Ft.—In.	Nominal base square B Ft.—In.	Water table opening D Ft.—In.
10	80–0	20–0	5–6
11	87–0	20–0	5–6
12	94–0	24–0	5–6
16	122–0	24–0	5–6
18	136–0	26–0	5–6
18A	136–0	30–0	5–6
19	140–0	30–0	7–6
20	147–0	30–0	6–6
25	189–0	37–6	7–6

Tolerances: A, ±6 in. B, ± 5 in. D, ± 2 in.

The height "A" of an API conventional derrick is the distance measured along the neutral axis of the derrick leg from the top of the derrick floor joists to the bottom of the water table beams or bumpers.

The base square dimension "B" is the distance between the neutral axis of adjacent legs at the top of the derrick floor joists.

The water table opening dimension "D" is the inside or in the clear dimension of the opening in the water table.

The gin pole structure is used to lift crown components from the derrick floor to the top of the derrick and through the water table. It is constructed to extend across the center of the water table opening. The minimum clearance between the horizontal header of the gin pole and the tops of the water table beams is 8 ft for derricks under 122 ft in height; 10 ft for 122-ft derricks; 12 ft for 136-ft derricks, and 17 ft for 140, 147, and 189-ft derricks. Usually higher gin poles if desired may be obtained on special order.

*Consulting Engineer, Santa Ana, California.

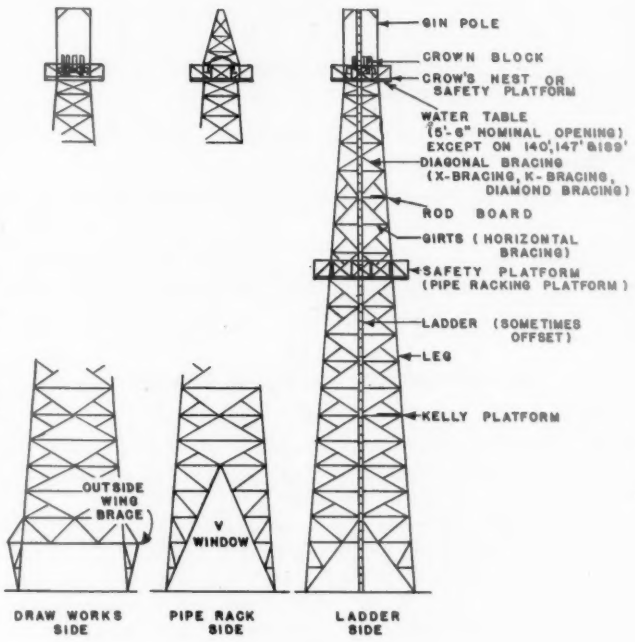

FIG. 1. Derrick nomenclature.

A safety platform is usually placed around the crown which conforms to the various safety codes.

As can be seen from Fig. 1 the horizontal members are called girts and the cross bracing called diagonals. Cross bracing comes in several forms depending upon the manufacturer. Typical examples are X bracing, K bracing and diamond bracing.

The "V" window opening used for rotary drilling is provided to permit the drawing of pipe from the pipe rack into the derrick. The minimum height of the window opening measured in the clear parallel to the centerline of the derrick side from the top of the derrick floor joists is 23 ft, 8 in. for the 136-ft and smaller derricks, and 26½ ft for the 140, 147, and 189-ft derricks.

Derricks used for rotary drilling have a clear opening on the draw works side. For the 94, 122, and 136-ft derricks this is a minimum of 10 ft to each side of the centerline of the derrick and 7½ ft above the top of the floor joists. For 140, 147, and 189-ft derricks no actual minimum is specified except that the area on the draw works side of the derrick between the legs, the first girt and the floor joists shall be clear of any cross bracing or interfering members. Hence, the design of the derricks utilizes outside bracing called "wing bracing."

Additionally practically every derrick manufacturer makes some derricks which are outside the API standard dimensions.

Capacity of Conventional Derricks

Capacities of conventional derricks run from as little as 86,000 lb to as much as 1,392,000 lb. The API safe working load capacity (not failure) is the maximum dead load

the derrick is designed to support with a factor of safety of approximately 1.94. This value, given on the nameplate attached to the derrick, is the allowable column load capacity of a single derrick leg multiplied by 4. A factor of safety of approximately 1.94 is provided in the API column formula to provide for the added effect of wind loads, drill pipe setback in the derrick, dead weight of the derrick, dynamic loads, and the effect of anchoring the dead line in different positions.

With respect to this latter item it should be noted that the safe working capacity changes when the dead line is anchored in different positions. These are as follows:

1. Anchored in corner opposite draw works side — reduces capacity 20 per cent.

2. Anchored at calf wheel opposite draw works — reduces capacity 7 per cent.

3. Anchored at corner on same side as draw works — reduces capacity 40 per cent.

Actually these are somewhat approximate deductions as they will vary between hook load, single line pull and number of lines strung to the block.

Design of Conventional Derricks

The design requirements for conventional derricks is well covered in API Standard 4A. Therefore it is the intent of this article to briefly explain how the specification is used in the design of a conventional derrick.

Almost the complete stress analysis of a conventional derrick can be solved graphically, and a typical space and load diagram for the applied wind loads and pipe set back is shown in Fig. 2. From these loads the stresses in the various members can be determined. For members in tension the member load is merely divided by the net cross sectional area to give the tensile stress in pounds per square inch. For members in compression the API column formula is used. This also is used to determine the allowable column load of derrick legs in compression.

Since the advent of portable and mobile mast structures introduced many steels of various yield points a new API formula was adopted to fit all steels and this is given as follows: (From Table 1 of the API Standard 4D Specification for Portable Masts.)

Compression:

Columns, gross section

for $KL/_r$ less than $24{,}000/\sqrt{y}$

allowable unit stress

$= [Y/1.941] - [Y^2(KL/_r)^2/2.245 \times 10^9]$

for $KL/_r$ greater than $24{,}000/\sqrt{y}$

allowable unit stress

$= 149 \times 10^6/(KL/_r)^2$

where

K = effective column length factor. (This can be left as 1.0 if the designer desires not to take advantage of a possible reduction in effective column length) (For conventional derricks K is assumed to be 1.0).

L = column length in inches.

r = radius of gyration.

A family of curves based on these formulae has been prepared and is shown in Fig. 3. Instructions for use of these curves are as follows:

1. Determine the minimum yield point of the steel being used. (For example — mild structural steel would be 33,000 psi minimum yield point; — silicon structural steel would be 45,000 psi minimum yield point;— Bethlehem Mayari R or U. S. Steel Corten would be 50,000 psi minimum yield point; — SAE 4130 in the normalized condition would be 75,000 psi minimum yield point etc.)

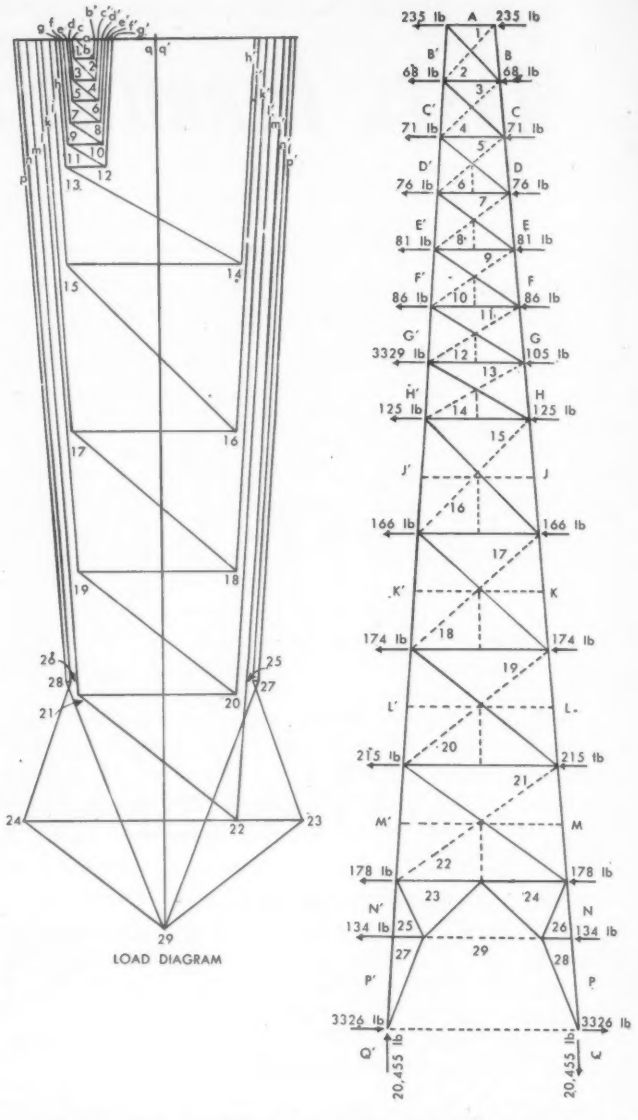

FIG. 2. Typical space and load diagram for graphical analysis of conventional derrick.

2. Determine the effective column length in inches. (Same as actual for conventional derricks).

3. Determine the radius of gyration. This can be obtained from a handbook or can be calculated.

4. Determine the cross sectional area in square inches of the member or column in compression.

5. Divide the effective column length by the radius of gyration to obtain the slenderness ratio. $(L/_r)$. This will be $KL/_r$ if the effective column length rather than the actual column length has been used.

6. From the chart shown as Fig. 3 select the column curve corresponding to the minimum yield point of the steel used. Read up from the calculated $KL/_r$ and across to the allowable unit column stress in pounds per square inch.

7. Multiply the allowable unit stress by the cross sectional area of the member to obtain the allowable column load. This is the load the member will safely carry with a factor of safety of approximately 1.94.

Wind Load

The wind load in miles per hour is calculated from the following formula:

$P = 0.004V^2$

where:

P = unit wind load in pounds per square foot
V = actual wind velocity in miles per hour.

Actual wind velocities corresponding to unit wind loads of 11.76, 22.50, and 52.90 psf are 54, 75, and 115 mph respectively. (An actual wind velocity of 54 mph is equivalent to 70 mph indicated velocity as determined by the Robinson 4 cup anemometer.)

The minimum unit wind load for the 80, 87, 94, 122, and 136 ft derricks with pipe set back is 11.76 psf. (54 mph actual wind velocity). The minimum unit wind load for the 140, 147, and 189 ft derricks is 22.50 psf with pipe set back and 52.90 psf without pipe set back.

The application of wind load considers that the wind load is applied to the exposed area of two directly opposite sides of the derrick and also to the pipe set back standing in the derrick. Additionally the horizontal component of the weight of the pipe set back is assumed acting at the pipe racking platform. For the convenience of the engineer, user, and designer, Table 3 in API Standards No. 4A gives proper values for pipe set back weight and wind loads in conventional derricks.

Additionally a diagonal wind loading must be considered. To provide for this contingency, the legs, leg splices, and anchorage are designed to resist loads 1.414 times those previously mentioned.

Other items which are considered in the design calculations of conventional derricks include:

For joints, girts, and braces in addition to the wind loads and pipe set back loads already mentioned, a load condition consisting of three co-acting loads is as follows:

1. A concentric crown block load equal to 1.2 times the derrick maximum safe load, assumed as acting concentric with the derrick.
2. A pipe set back load previously mentioned.
3. A horizontal load of 3000 lb or 0.01 times the maximum safe load of the derrick, whichever is the least, applied at the top of the derrick leg at one corner of the derrick, in the plane of the derrick side and in the same direction as the horizontal component of the pipe set back weight.

For heavy girts on opposite sides of the derrick used for the support of the working platform, derrickman, pipe tong, and counterweights, the girts must be designed to sustain a 1200 lb load 3 ft from the derrick leg or adjacent derrick side.

And the water table beams are designed in accordance with the folowing formulas.

For derricks 136 ft and shorter

$$W = \frac{12\,M}{L} = \frac{12\,(S_m)\,(f_c)}{L} \text{ or } 570{,}000 \text{ lb}$$

whichever is smaller.

For derricks 140 ft and higher for both 6½ ft and 7½ ft water table openings

$$W_t = \frac{15\,M}{L} = \frac{15\,(S_m)\,(f_c)}{L}$$

where

W or W_t = maximum safe load for two water table beams in pounds.
M = Bending moment in inch-pounds.
L = distance in inches between neutral axes of legs at the bottom of the water table beams or between the load axes if derrick is reinforced.
S_m = section modulus of one water table beam in inches.[3]

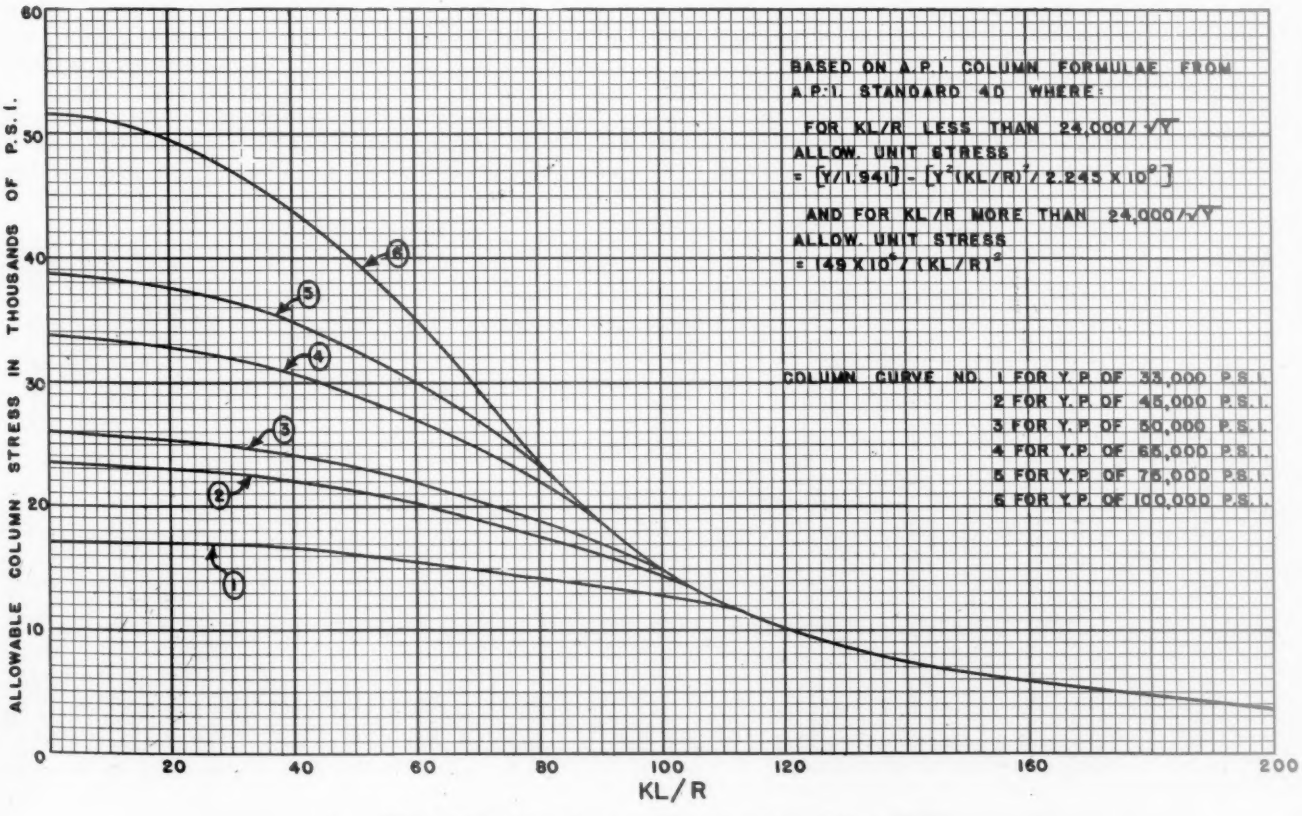

FIG. 3. Allowable column stresses for various Y.P. steels.

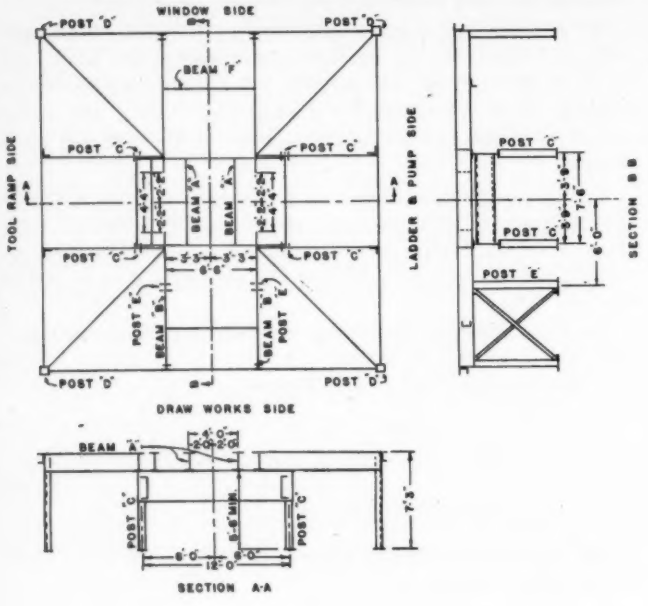

FIG. 4. Type "A" substructure.

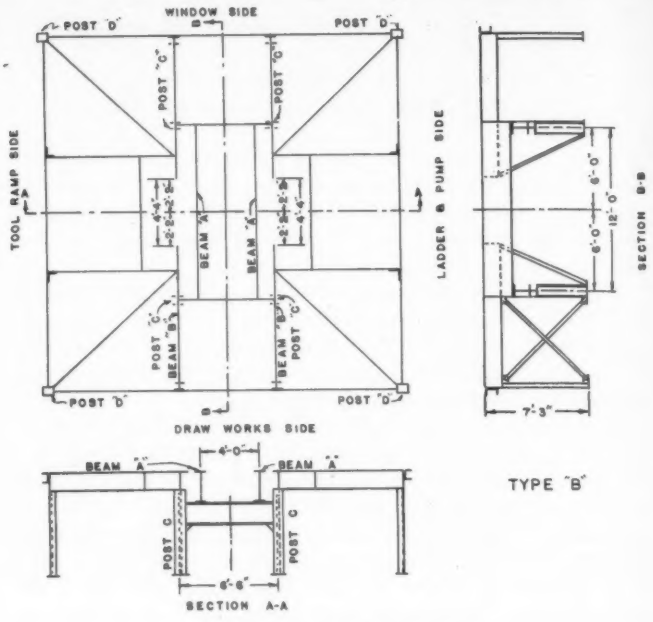

FIG. 5. Type "B" substructure.

f_c = allowable unit stress on extreme fibers as stipulated by API Standards 4A in pounds per square inch.

Selection of Proper Derrick Capacity

There is considerable argument concerning the proper way to select derrick capacity. One method is to match the draw works to the derrick. Thus if a draw works has a known maximum bare barrel line pull then this line pull times the maximum number of lines to be strung to the block plus the pull of the fast and dead line and the effect of the dead line position should not exceed the safe load capacity of the derrick.

Another method is to determine the safe load capacity from the hook load required to part a casing joint by jarring if the casing is stuck in the hole. Assuming a casing string of known size and joint strength is first necessary — which will equal the required hook load — after which the required number of lines and line pull can be determined with the effect of the fast and dead line and their position effect added in to determine proper safe capacity of the derrick.

Substructures for Conventional Derricks

The API has now adopted 3 types of substructures for use with conventional derricks. These are Type A shown in Fig. 4, Type B shown in Fig. 5, and a Truss or Girder type — a typical example of which is shown in Fig. 6. Additionally pedestal type substructures to permit step down drives such as shown in Fig 7 are also used. Also there are numerous variations in the Truss or Girder type.

The Type A substructure is designed to permit the pipe set back and rotary loads to be carried separately when it is desirable because of soil conditions. This is accomplished

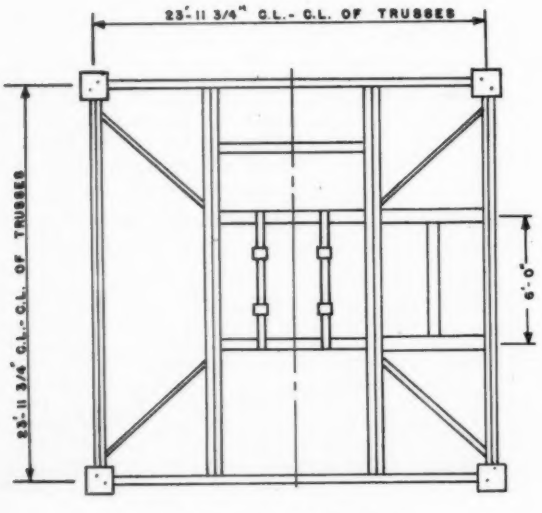

FIG. 6. Truss type substructure.

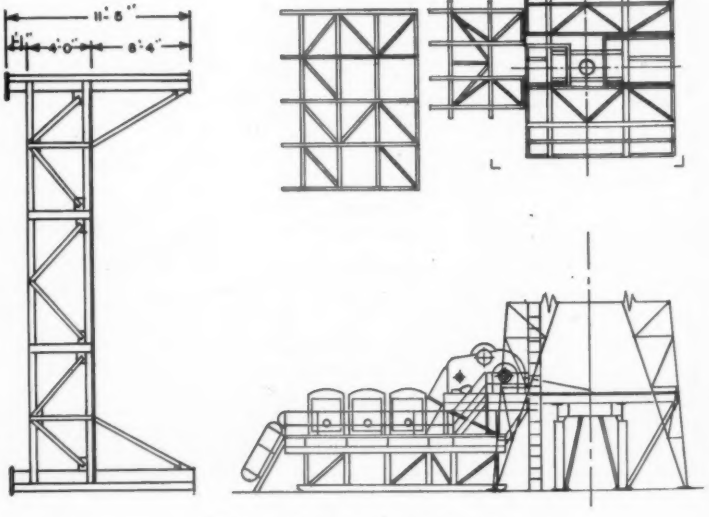

FIG. 7. Pedestal type substructure.

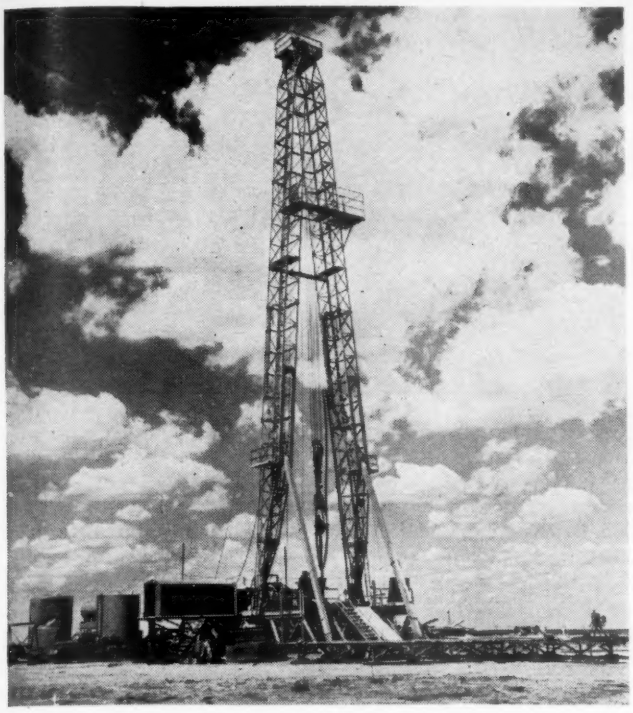

FIG. 8. Ideco full view drilling mast (free standing).

by the use of six foundation piers. The Type B substructure uses four foundation piers to carry the pipe set back and rotary table loads. With the Type A substructure the blowout preventer equipment is lowered through the derrick floor while with the Type B it may be withdrawn to the side from beneath the floor. Usually with the Truss types it may also be taken in or out from underneath.

The height of Type A and B substructures has been standardized as follows:

Base size feet	Substructure height
24	7.25
26	7.25
30	7.25, 10* or 14*
37.5	14*

*Tentative.

The substructure height is the vertical distance from the bottom of the corner post base to the top of the substructure framing sills on which the floor joists rest.

In the design of substructures the API Standards 4A advises as follows:

For truss or girder type substructures having a four

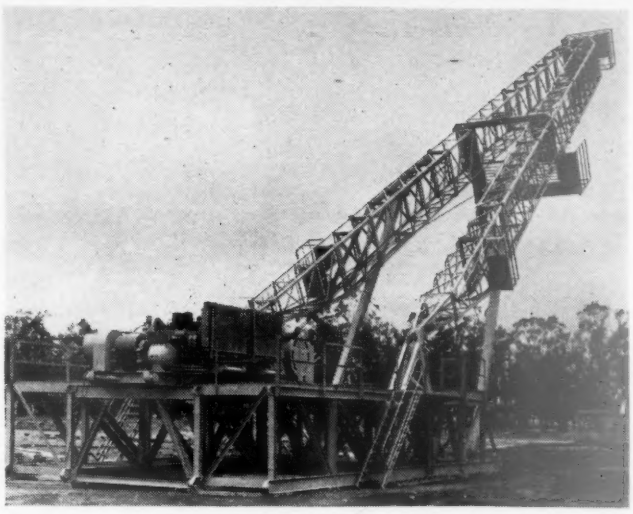

FIG. 9. Ideco full view mast — FM 128-360 mast (during erection); 8-in. high single level subbase; Ideco Hydrair H-525 draw works.

point support the corner columns shall be designed for *two* loading conditions as follows:

a. Weight of casing and pipe set back acting *simultaneously*.

b. Derrick loading and weight of pipe set back acting *simultaneously*.

Assumed minimum loads for substructures are given as follows:

Substructure base size, feet	Derrick loading pounds	Casing load pounds	Pipe set back load pounds
24	700,000	300,000	150,000
26	950,000	450,000	200,000
30	950,000	450,000	200,000
30	950,000	600,000	350,000
37.5	950,000	750,000	450,000

The casing and pipe set back loads were determined as follows:

For the 24-ft base size, the pipe set back load of 150,000 lb is based on 8000 ft of 4½-in. 16.6-lb drill pipe with a full hole tool joint at each connection (18.5 pounds per foot). The casing load of 300,000 lb is based on 800 ft of 28 lb casing and an impact factor of 33⅓ per cent.

For the 26 and 30-ft (136-ft height) base sizes, the pipe set back load of 200,000 lb is based on 11,000 ft of 4½-in. 16.6 lb drill pipe with a tool joint at each connection (18.5 pounds per foot). The casing load of 450,000 lb is based on 7500 ft of 45 lb casing or 11,000 ft of 30 lb casing and an impact factor of 33⅓ per cent.

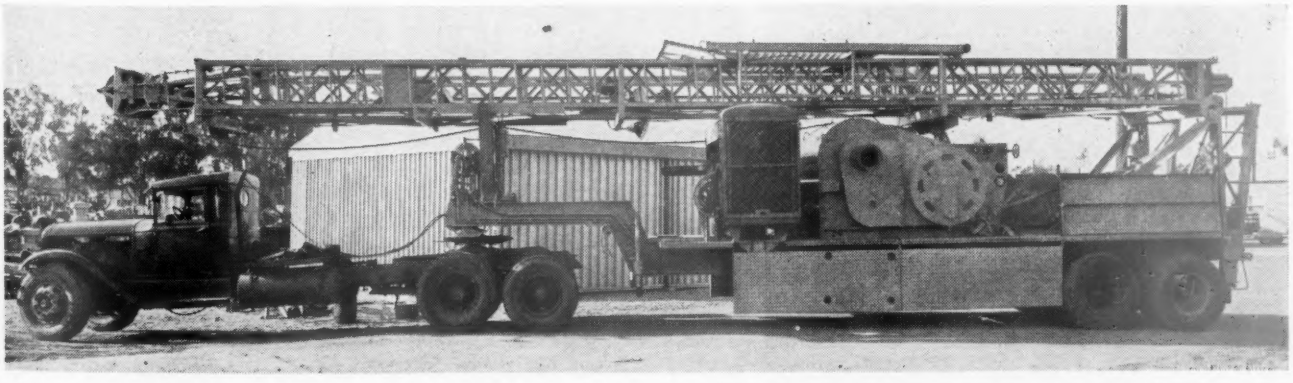

FIG. 10. H-25 Rambler with H-25D Hydrair hoist, Waukesha WAKU engine with twin disc torque converter, KM95 KWIK-Lift Telescoping mast; T-25T-A servicing and workover semi-trailer, and workover 50-ton substructure (6 ft 6 in.).

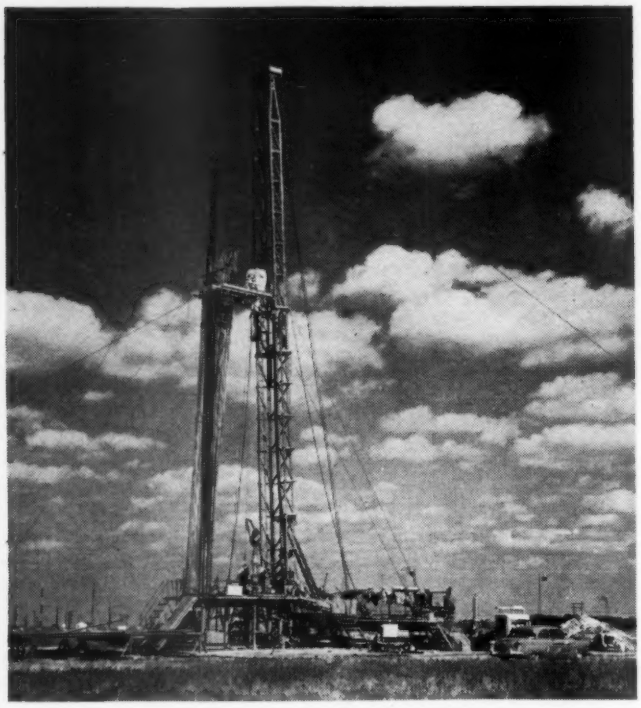

FIG. 11. Ideco H40 D Rambler Rig with 103 ft 250,000 lb hook load capacity telescoping mast.

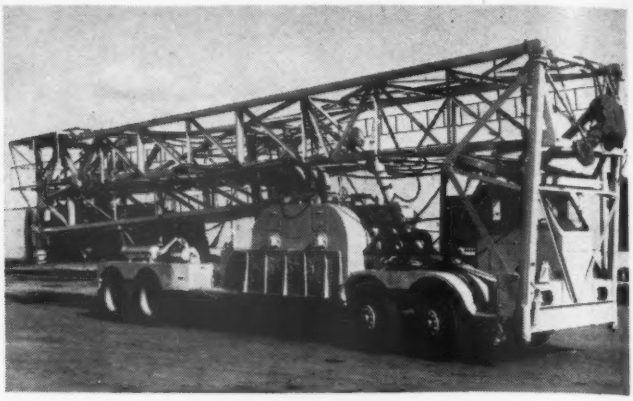

FIG. 12. Hopper drive-in unit with 96 ft folding mast.

For the 30 ft base (140 and 147-ft height) size, the pipe set back load of 350,000 lb is based on 15,500 ft of 5-in. 19.5 lb drill pipe with a 4½-in. IF tool joint at each connection (22.5 pounds per foot). The casing load of 600,000 lb is based on 10,000 ft of 45 lb casing or 15,000 ft of 30 lb casing and an impact factor of 33⅓ per cent.

For the 37½ ft (189-ft height) the pipe set back load of 450,000 lb is based on 20,000 ft of 5-in. 19.5 lb drill pipe with an IF too joint at each connection (22.5 pounds per foot). The casing load of 750,000 lb is based on 12,500 ft of 45 lb casing or 18,750 ft of 30 lb casing and an impact factor of 33⅓ percent.

For Type A and B substructures the casing load on beam A is considered as two concentrated loads, equal to one-fourth of the specified casing load and distributed as shown in Fig. 6 of API Standards 4A.

Also for Type A and B substructures the pipe set back load is considered as two-thirds the specified pipe set back load, uniformly distributed over two-thirds the length of one pipe set back beam as shown in the aforementioned Fig. 6 of API Standards 4A.

Truss or Girder type substructures are designed to support the pipe set back to the right of the driller as he faces the well.

Design of these substructures avoids any direct loads carried by fastenings such as bolts and rivets in shear. Derrick legs are properly centered over the corner column.

The foregoing has dealt with standard API substructures There are many other types. Sectional unitized bases to permit ease in skidding the derrick with uniform distribution of loads to a drilling mat of concrete or heavy plank-

FIG. 13.

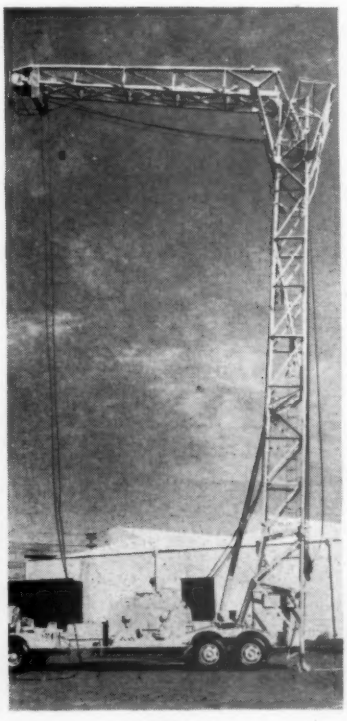

FIG. 14.

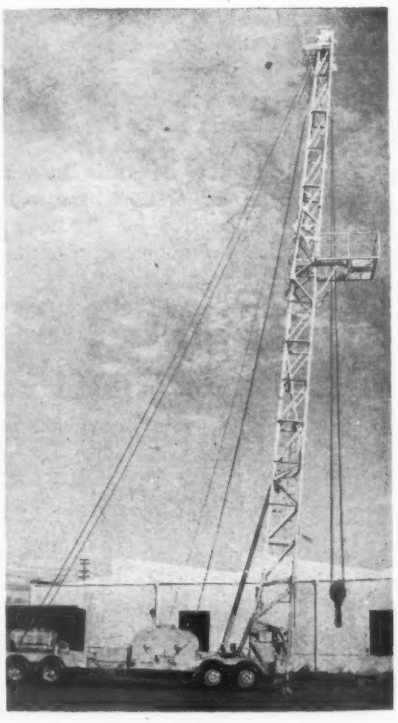

FIG. 15.

Hopper drive-in unit with folding mast in operation.

ing are frequently used. Also substructures having 14 posts for more direct load transfer to the ground have been used. The main problem is always to design the substructure to properly carry the loads with an ample factor of safety. API Standards 4A should be used as a general guide for all substructures including special or modified ones.

Portable Derricks and Masts

Portable derricks and masts fall into two groups — free standing and mobile. The free standing mast is usually a vertical or near vertical mast made of several individual sections fastened together and mounted on a separate skid or base. Typical example of this type are the Ideco Full Vue shown in Figs. 8 and 9 and the Bender-Ideco Full Lever Lift, the Lee C. Moore Cantilever Mast and the Oilwell free standing portable derrick.

These derricks or masts are usually wire line raised with the hoist and traveling block. Fig. 9 shows one method of wire line raising that incorporates the use of lever lifting arms which become part of the structure when the mast is erect. Another Bender design, which is quite popular in California, is hydraulically raised. Free standing masts or derricks are self supporting and stable without the use of external guys to the ground although wire line bracing might be used to the sub-base or mast support frame.

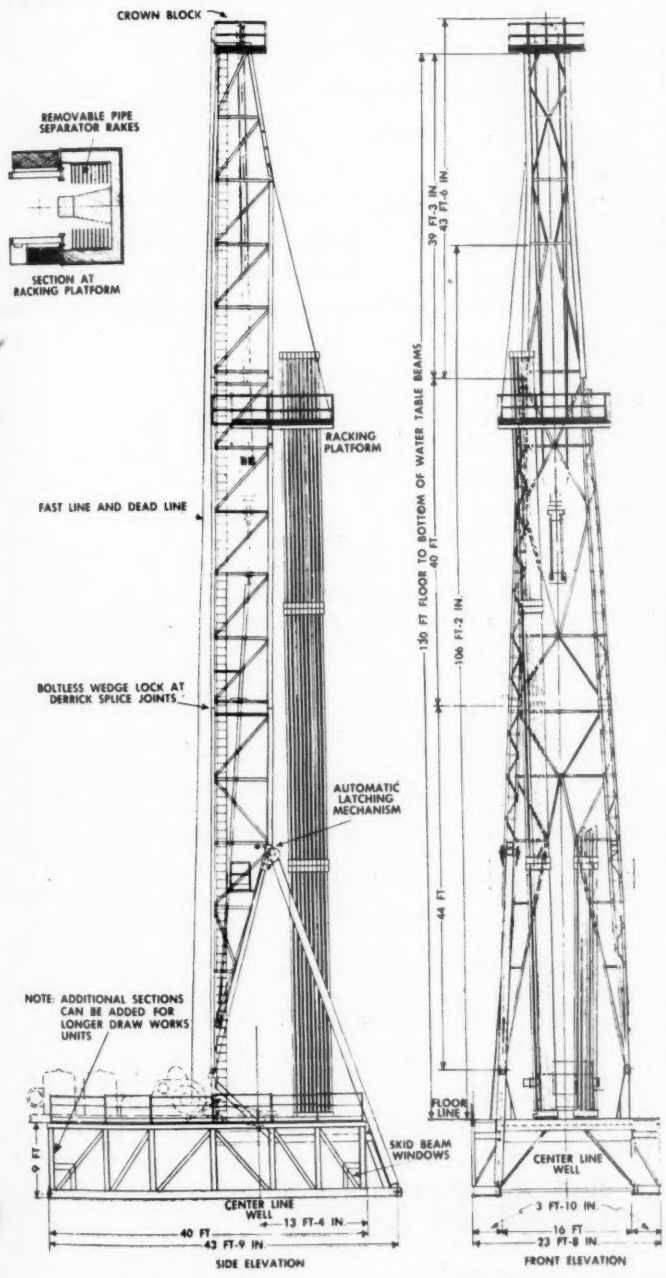

FIG. 16. Double trussed box type portable mast.

Mobile masts or open face derricks as they are sometimes called, consist of several types. First to be considered is the single and double pole telescoping pipe masts. These are made of telescoping pieces of pipe which extend to two or three times their collapsed height. Modern designs of this type of mast include a racking platform and are frequently made tall enough to handle doubles. The biggest difficulty with designs of pole masts is their extreme slenderness which makes them require a multiplicity of guy wires to several ground positions. For shallow well servicing with light weight equipment, however, they do a good job.

Because of the limitations of the pole mast designs the single frame or lattice type derrick was introduced about 1935. Originally it was designed to handle singles of range 2 but later was made tall enough to handle doubles. Such derricks are now used on large core drills and slim hole drilling rigs. All are wheel mounted either truck or trailer complete with drilling equipment.

Following the single piece lattice or trussed type construction mast came the development of the modern telescoping derrick. Usually these derricks are 90 to 103 ft high and are suitable for handling doubles of range 2 for drilling and servicing. A triple telescoping mast has been designed recently, however, having enough height to handle triples of range 2.

Short telescoping derricks are also made for mounting on smaller self propelled vehicles for shallow well servicing. These are usually 55 to 65 ft in height with hook load capacities of 75,000 to 150,000 lb. Taller telescoping derricks in the 90 to 103 ft height have hook load capacities of 150,000 to 300,000 lb. An example of a trailer mounted mobile type telescoping derrick is shown in Figs. 10 and 11.

Also of importance is the folding derrick which is competitive in both the shorter and taller heights to the telescoping derrick. These derricks are raised hydraulically as in the case of the Hopper or by a chain mechanism as in the case of the Lee C. Moore. Figs. 12, 13, 14, and 15 show the Hopper folding derrick mounted on a drive-in self propelled type chassis in the process of erection.

Many types of chassis are used for carrying mobile type derricks. These include tractors, trucks, trailers, self-propelled vehicles, and the new drive-in type self-propelled vehicle. This last type which is currently being made by Hopper, Ideco, Franks, Wagner-Morehouse, and Wilson has many advantages.

First, the unit drives into the well location instead of backing in resulting in a faster, safer approach. Second, the weight on all wheels is more nearly balanced and most of the units more nearly comply to highway regulations. Third, the same large engine and torque converter used for driving the hoist is used for driving the vehicle over the road.

Mobile derricks or masts are used for both drilling and servicing operations. They are easily and quickly spotted and erected (usually less than 30 minutes) and travel with the lines and blocks always strung so that they are ready for work as soon as they are erected in position. They eliminate the need for permanent derricks with the accompanying large capital investment. Indeed, there are now many oilfields in which there is not a single permanent derrick as all the servicing work is handled by portable derricks.

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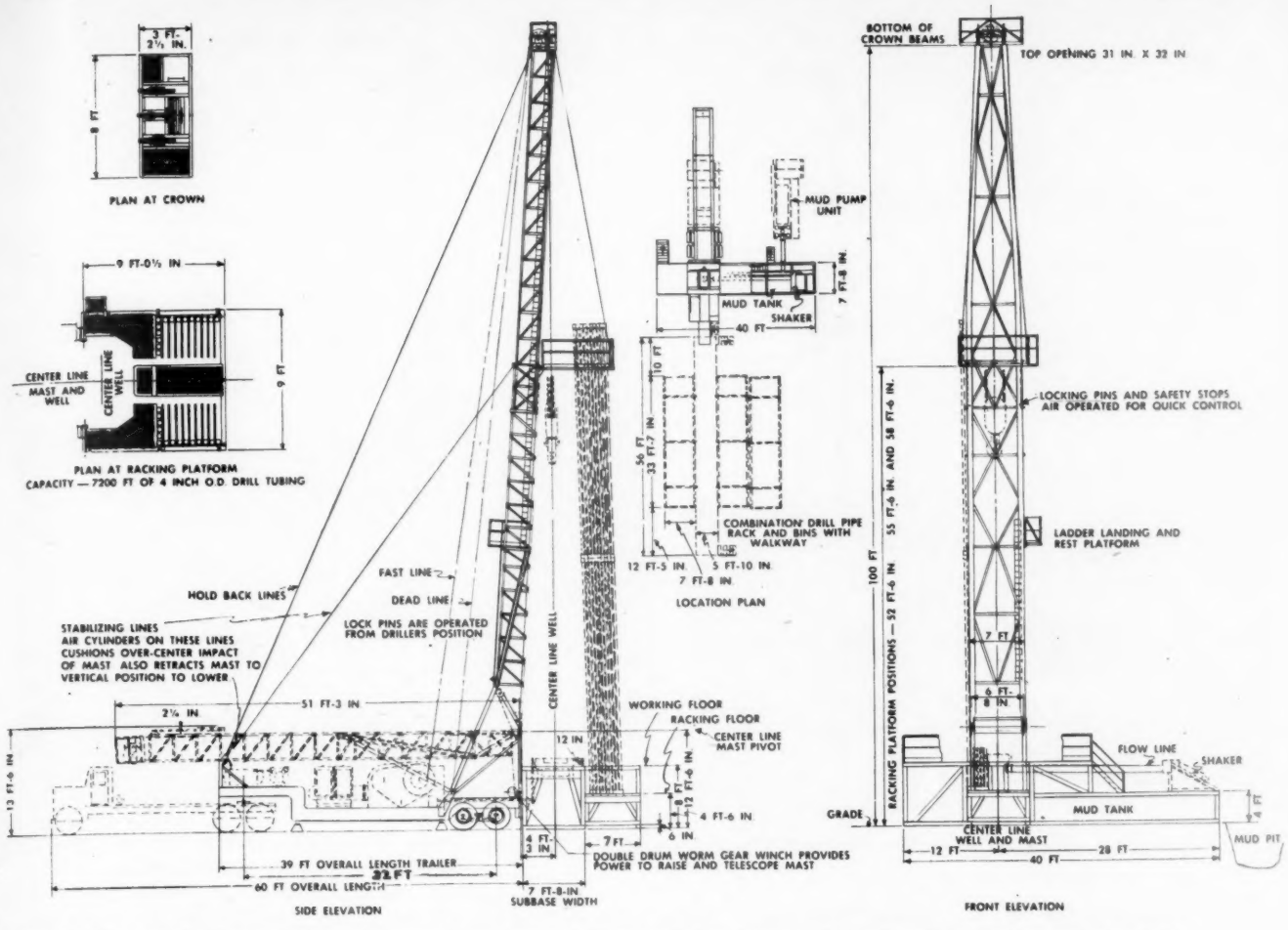
PLAN AT CROWN
PLAN AT RACKING PLATFORM
CAPACITY — 7200 FT OF 4 INCH O.D. DRILL TUBING
SIDE ELEVATION
LOCATION PLAN
FRONT ELEVATION
BOTTOM OF CROWN BEAMS
TOP OPENING 31 IN. X 32 IN.
MUD PUMP UNIT
MUD TANK
SHAKER
LOCKING PINS AND SAFETY STOPS AIR OPERATED FOR QUICK CONTROL
LADDER LANDING AND REST PLATFORM
COMBINATION DRILL PIPE RACK AND BINS WITH WALKWAY
FAST LINE
DEAD LINE
HOLD BACK LINES
STABILIZING LINES
AIR CYLINDERS ON THESE LINES CUSHIONS OVER-CENTER IMPACT OF MAST ALSO RETRACTS MAST TO VERTICAL POSITION TO LOWER
LOCK PINS ARE OPERATED FROM DRILLERS POSITION
CENTER LINE WELL
WORKING FLOOR
RACKING FLOOR
CENTER LINE MAST PIVOT
RACKING PLATFORM POSITIONS — 52 FT-6 IN. 55 FT-6 IN. AND 58 FT-6 IN.
FLOW LINE
SHAKER
MUD TANK
GRADE
CENTER LINE WELL AND MAST
MUD PIT
39 FT OVERALL LENGTH TRAILER
32 FT
60 FT OVERALL LENGTH
DOUBLE DRUM WORM GEAR WINCH PROVIDES POWER TO RAISE AND TELESCOPE MAST
7 FT-9-IN SUBBASE WIDTH

FIG. 17. Mast for drilling available with trussed box frame structure carrying rotary table, mud system, shakers and pipe rack.

Design of Portable Masts

The design of portable masts or derricks is not nearly so limited by API specification as is the design of conventional derricks. The API does have a tentative specification for portable masts, however, and this is API Standard 4D. Generally speaking the same forces acting upon a conventional derrick act upon a portable derrick. These are the compressive leg loads due to hook loads, fast and dead line loads, hold back guy loads, wind loads, and pipe set back loads.

Loads in members are usually determined by graphical analysis although the analysis is usually more involved than that of conventional derricks. Compressive column stresses and allowable loads are determined by the same method previously described using the API formula or the family of curves shown in Fig. 3. Wind loads on the mast and on the pipe set back are considered to be 11.76 psf (54 mph actual wind velocity).

Practically all portable masts are of welded construction. The legs are made of either tubes or structural shapes. Some manufacturers make their own square or rectangular tubes from structural shapes by welding angles or channels together. As the API formula for columns is based on a K factor of 1.0 as the value for a pin end condition some improvement of the end condition value can be expected for design purposes in a mast of this type. In other words because of the fixing properties of the adjoining members and the carry-through effect of a welded structure a better fixity value (K) may be used in place of a pin end condition where K = 1.0.

To determine a proper K value the API has tentatively introduced a method using the number of attaching members, their length, and moment of inertia. As this has not been released at the time of this writing it will not be covered but it appears that for most masts in use today the K value at station points or column ends will be between 0.80 and 0.90.

The following items of general interest are also from API Standards 4D.

The height of a portable mast (other than single pole types) is the vertical distance from the horizontal plane through the foot of the mast legs (or from the lower side of the mast base if the mast is anchored to the mast base) to the lowest member which may contact, and thereby limit the rise of the traveling block.

The height of a single pole mast is the vertical distance from the centerline of the lowest crown sheave to the foot of the mast leg.

The height of a free standing portable mast is the vertical distance from the top of the floor support beams to the lowest member which may contact and thereby limit the rise of, the traveling block.

Load Guylines for Guyed Masts

Each guyed portable mast shall be provided with two load guylines attached as close to the top of the mast as possible. Each guyline shall have a breaking strength of at least 2½ times the maximum calculated guyline load. If stabilizing guys are used they also must have a breaking strength of at least 2½ times the calculated guyline load and they cannot be less than ⅜-in. diameter.

Mast Capacity

Most portable masts (at least of the mobile type) are now rated primarily by hook-load capacity with a certain

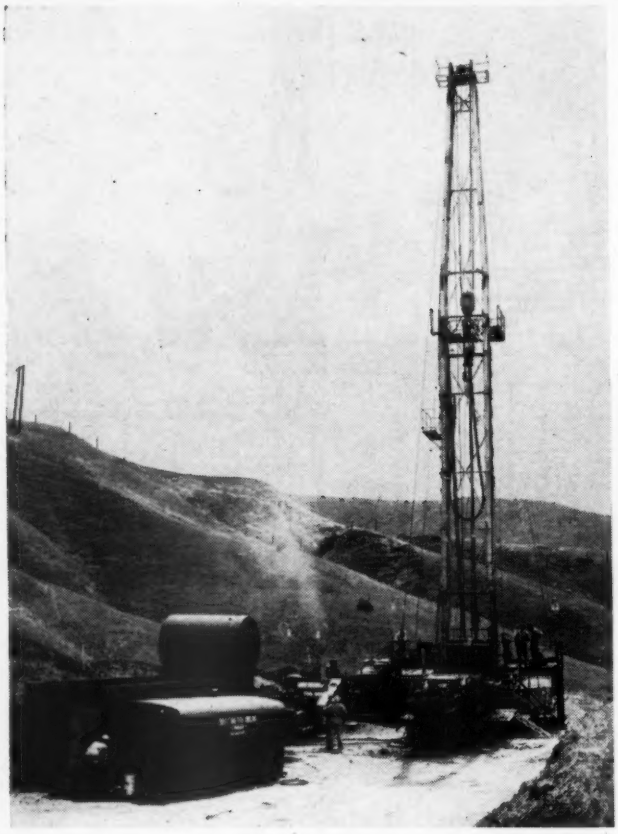

FIG. 18. Rear view, Bender 100-ft mobile drilling mast.

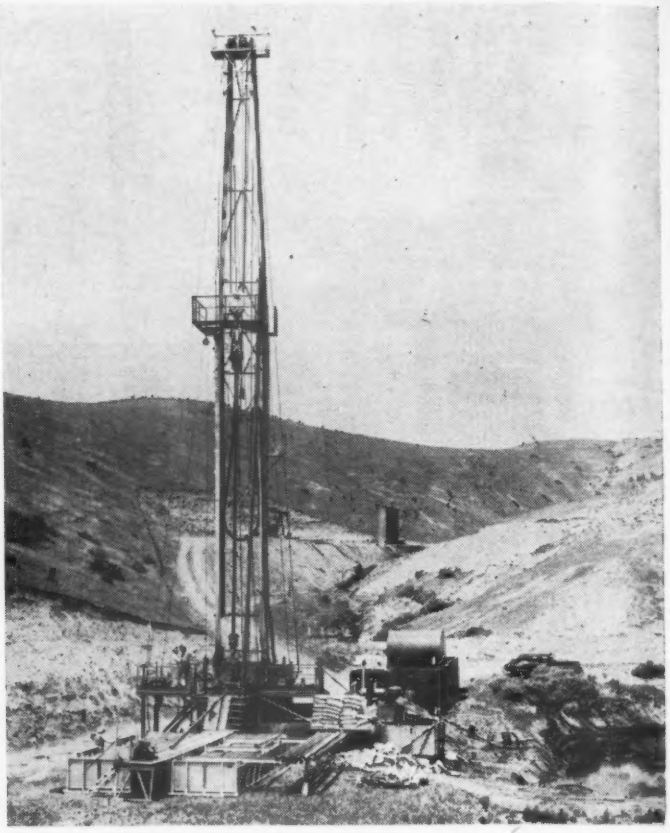

FIG. 19. Front view, Bender 100-ft 240,000 hook load capacity mast.

number of lines to the traveling block. To obtain the gross capacity of the mast for the same number of lines strung up, the effect of the fast line, dead line, and hold back guys must be added in.

It should be noted that this is not necessarily the gross column capacity of the mast (as in the case of a conventional derrick). It is merely the gross load imposed upon the mast under a given set of conditions. Changing the number of lines up or the position of the crown sheaves greatly modifies the input loads and their positions and influences the load carrying ability of the mast. Such changes should not be made without the advice of the manufacturer.

Substructures for Portable Masts

As yet there is no API specification for portable mast substructures. Naturally it is expected that all manufacturers follow the material specifications and formula already laid down in API Specifications 4A and 4D.

There are about as many types and makes of substructures for portable masts as there are portable masts. Perhaps the most popular type for free standing masts is the trussed double box type as shown in Figs. 16, 8, and 9. This type consists of 2 box like structures of truss frame construction approximately 4 or more feet wide by 9 ft high and about 44 ft long.

The reason these dimensions are so popular is that 2 of these box structures when carried on a trailer bed 48 in. or less in height make a legal load in many states. Tying the 2 box structures together when in use are cross members at the top and bottom and knee braces.

The cross members are designed to carry rotary table loads, drill pipe loads, draw works, and engine loads into the substructure and thence into the ground. Often the bottoms of these box structures are covered with metal plate to provide greater bearing to the soil. Or sometimes a location is prepared simply by leveling and laying down heavy planking.

It is common practice for manufacturers to make substructures of this type in various heights and widths ranging from 5 to 10 ft high and 4 to 6 ft wide and any length to fit the draw works and engine combination.

For mobile types of portable masts, ramps and folding shelf type platforms are often used. When the mast is to be used for drilling, a trussed box frame structure carrying the rotary table, mud system, shakers, and pipe rack all in one package is available. Such an arrangement is shown in Figs. 17, 18, and 19 along with a 100 ft lever lift mast and a unitized pipe rack with pipe bins.

The whole idea behind the mobile mast units is to provide a complete unit of extreme compactness on wheels to reduce moving and rig up time. All component assemblies including substructures are designed with this in mind.

Care and Use of Derricks and Masts

The API Standards 4A and 4D have an exceptionally complete set of instructions on this important item. Briefly it can be said that a properly set up derrick or portable mast simply will not fail if it is not overloaded or tampered with. Too often failures do occur because members have been removed, altered, or because the derrick is loaded eccentrically or in a way not intended by the designer. It is usually the intention of the engineer and manufacturer to make every member a working member in one way or another and their removal or alteration to make room for other equipment is an extremely hazardous practice.

The API recommendation is a good check list to follow when using either conventional derricks or portable masts as it encompasses every part of the use and maintenance of masts and derricks including welding, footings, soil bearing capacities, tie down, locking sections together, wire line and hydraulic raising, lubrication, and loads.

MODERN DRILLING

What to Do About Lost Circulation-4

by J. M. Bugbee The Oil and Gas Journal, May 3, 1954

"Much West Texas drilling is done with water because it is the cheapest and fastest drilling fluid. It is understandable that losses to the formation can be continuous and, for example, a loss of 15 bbl. per hour is not considered serious.

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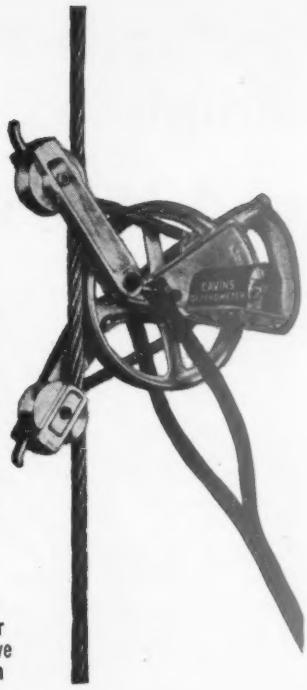

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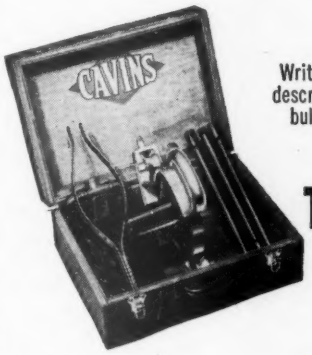

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Simplified Techniques of Determining Calcium and Magnesium Content of Carbonate Rocks

Ratio of calcium to magnesium in carbonate outcrops may prove valuable geologic tool. Quick determination methods are reviewed

GEORGE V. CHILINGAR and RICHARD D. TERRY

AS pointed out by Chilingar,[2] the Ca/Mg ratio in limestones is a very useful geologic tool. It is especially useful as a geologic thermometer and in porosity studies. Due to the length of time, however, required in standard techniques for determining calcium and magnesium content, it generally was not possible to make it a routine analysis. In order to correct this shortcoming, the authors reviewed the literature and found several rapid and accurate methods. In addition, examples of their accuracy are presented. The thermal analytical method was translated from Russian and, therefore, is presented in some detail here. As Tsvetkov's article of the thermal apparatus has no diagram, the authors have taken the liberty of making a schematic sketch (Fig. 1) of their interpretation of Tsvetkov's device.

Versenate Method

An excellent method has been developed by Cheng, Kurtz, and Bray[1] based on the complex action of disodium salt of ethylene diamine tetraacetic acid (Versenate). This method involves two titrations, one for calcium content, and the other for both calcium and magnesium. The difference between the two titrations is the volume of "Versenate" needed to titrate the magnesium. Each analysis, including calculations, requires only about 25 minutes. Iron, aluminum, manganese, and phosphorous interfer with the magnesium determination. These interfering substances, however, are generally present in very small amounts in limestones and dolomites.

Cheng, Kurtz, and Bray show good agreement between the standard wet technique and the Versenate chemical analysis. In order to determine the accuracy of this method when performed on a routine basis, the present investigators also made several chemical analyses of limestone samples by the standard and Versenate techniques. Results are shown in Table I.

Powdering of limestone samples, especially some hard varieties, is a time-consuming procedure, so the possibility of using chips (<.2 cm in diam) instead of powdered samples was investigated. The chemical analyses of chips and powders of several limestone samples is shown in Table 2. These results are in close agreement.

Thermal Analytical Methods

Physico-chemical methods for determining the chemical composition of minerals are finding wider application every day. Of major importance is the thermal analytical method which is based on the fact that minerals give up water or carbon dioxide at very sharply defined temperatures. It is possible to determine the amount of various minerals in a mixture by measuring the gases emitted at various temperatures.

Zvyagintsev[4] discussed in some detail the possible dissociation reactions of limestones and dolomites when they are heated. On heating dolomitic limestone in a current of carbon dioxide, one can observe very sharp, characteristic losses in weight due to the dissociation of $MgCo_3$ component at temperatures between 700-800 C and then the $CaCo_3$ component between 900-950 C. By determining the losses in weight during these different stages of dissociation it is very easy to calculate the MgO and CaO content.

Berg proposed a new accurate and quantitative method of analysis of carbonate minerals based on the above described theory. In this method the volume of gases are accurately measured by an automatic burette as the sample is heated. Berg was able to make each analysis in less than an hour.

Tsvetkov[3] improved Berg's method by directly measuring the losses in weight during dissociation rather than the volume of gases. A schematic diagram of Tsvetkov's apparatus is shown in Fig. 1.

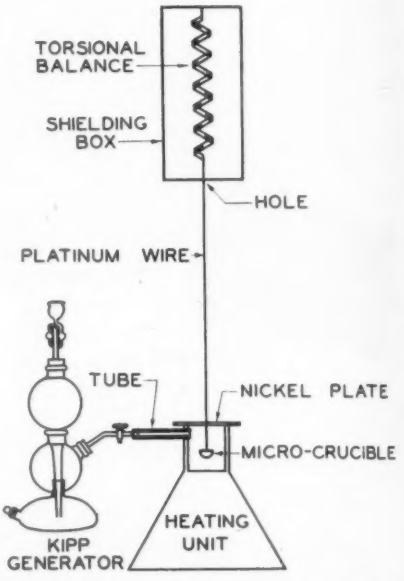

FIG. 1. Schematic diagram of "Thermal Apparatus."

A torsional balance permitting measurements up to 500 mg is used in this technique, and samples weighing around 200 mg are sufficient. As weights are visually estimated on the torsional balance with an accuracy up to 0.2 mg, the error in measurements is only about 0.1 per cent.

In order to prepare the apparatus for weighing continuously heated samples, it is necessary to make a round hole (diameter 5 mm) in the bottom of the balance box. The upper end of a thin platinum wire (diameter 0.03 to 0.05 mm), which is passed through this hole is attached to the weighing dish of the balance. Length of this wire should be about 70-80 cm and should go freely through the opening. A quartz micro-crucible, having a volume of about 0.1 cm^3 is attached to the lower end of this wire. Allowable weight of this empty crucible including the wire should be around 200 mg. The cruci-

EXCLUSIVE

TABLE 1. Calcium and magnesium determinations by standard wet technique and Versenate method.

Period	Formation	Standard method Ca per cent	Standard method Mg per cent	Versenate method Ca per cent	Versenate method Mg per cent
Ordovician	Saluda limestone, Indiana	19.9	7.11	19.70	7.00
Devonian	Devils Gate formation (upper contact), near Hamilton, Nevada	39.66	0.68	39.40	0.65
Mississippian	Lodgepole limestone, Madison group, Fergus County, Montana	35.85	1.86	35.50	1.60
Mississippian	Gardner formation, Utah: Sample No. C1-1	22.30	13.10	21.21	13.20
	Sample No. C1-5B	38.58	0.73	37.85	0.85
	Sample No. 10-AB	38.60	0.66	37.90	0.89
	Sample No. 19-C	39.10	1.63	38.78	1.69
	Sample No. 24-a	39.58	0.71	38.95	0.59
	Sample No. 24-c	34.48	2.70	34.28	3.00
Mississippian	Monte Cristo formation, Bullion limestone, near Mitchell's Caverns, California	33.58	2.04	33.54	1.90
Pennsylvanian	Maria Creek limestone, Indiana	34.8	1.94	34.90	2.00
Pennsylvanian	Ely limestone, Illipah Quadrangle No. 2, Nevada: Sample No. 7	39.40	0.30	39.2	0.42
	Sample No. 14	32.99	0.46	33.6	0.56
Pennsylvanian	Bird Springs formation, Nopah Range, California	37.58	1.33	37.90	1.13
Permian	Arcturus formation (crinoidal lower portion), Illipah Quadrangle No. 2, Nevada	35.36	0.42	34.96	0.50
Permian	Arcturus formation (arenaceous), Moorman Ranch, Illipah Quadrangle No. 2, Nevada	22.18	0.71	21.3	0.85
Permian	Middle of section, near Mitchell's Caverns, California	14.18	0.53	14.10	0.63
Pleistocene	Fresh water marl, Confusion Range, Utah	30.79	0.99	30.90	1.01

ble must hang in the middle of a heating unit, which allows heating up to 1200 C. In order to prevent the heating of the balance, large space must be left between the heater and the balance. During the analysis, the heater is connected to an electrical circuit at maximum intensity (5.5-6 A). As a result, the heating does not occur evenly, but gradually decreases. This method of heating is very convenient because the interval free from reaction (up to 600 C) passes with greater speed.

From the previous calibration with a thermocouple and plotted "time-temperature" curve, it is possible to determine the temperature at any given time. It is also possible to install a thermocouple directly into the heating unit.

A quartz or porcelain tube should be installed into the heater, and connected to a Kipp generator. It is advisable to have the end of this tube extrude out of the heater for 10 to 15 cm. After hanging the crucible with sample in the heating chamber, the upper opening of the heater is closed with a nickel plate having a slotted, round opening (diameter 5 mm). This plate decreases the convection currents in the heater, and is placed over the opening of the heater in such a way that the string will go through the middle of the opening.

TABLE 2. Calcium and magnesium content of limestone samples on using powder and chips.

Sample No.		Standard method Ca per cent	Standard method Mg per cent	Versenate method Ca per cent	Versenate method Mg per cent
C1-1	Powder	22.30	13.10	21.21	13.20
	Chips	22.10	13.40	20.91	13.40
M-1	Powder	22.18	0.71	21.3	0.85
	Chips	23.00	0.71	22.14	0.80
D-2	Powder	39.66	0.68	39.40	0.65
	Chips	39.80	0.71	39.50	0.67
C1-5B	Powder	38.58	0.73	37.85	0.85
	Chips	38.80	0.80	37.56	0.91

Tsvetkov's method of analysis can be summarized as follows:

(1) The weight of the string and microcrucible are measured before and after adding the sample. The difference is the sample weight.

(2) After making sure that the crucible is hanging freely in the heater, carbon dioxide is introduced into the unit by a Kipp apparatus.

TABLE 3. Analyses of limestones and Dolomites using thermal analytical method.

Sample No.	Tsvetkov method MgO	CaO	CO_2	Sum of carbonates	Standard wet chemical method MgO	CaO	CO_2	Sum of carbonates
15	20.83	29.37	45.83	96.03	20.50	30.58	46.36	97.44
16	21.06	31.41	47.68	100.15	21.36	31.72	48.20	101.28
17	20.96	31.38	47.55	99.89	20.96	31.36	47.48	99.80
20	21.17	31.27	47.68	100.12	21.30	30.52	47.19	99.01
21	21.35	31.13	47.78	100.26	21.51	30.68	47.54	99.73
22	20.78	31.69	47.59	100.06	21.06	31.17	47.44	99.67
29	20.68	31.69	47.49	99.86	21.25	31.75	48.10	101.10
32	21.08	31.11	47.45	99.64	20.64	30.89	46.76	98.29
33	20.77	31.55	47.47	99.79	21.10	30.98	47.34	99.42
34	20.72	31.54	47.41	99.67	21.42	31.02	47.70	100.14
36	21.35	31.08	47.73	100.16	21.24	31.20	47.66	100.10
40	20.51	31.70	47.31	99.52	21.13	30.72	47.16	99.01
46	12.87	40.47	45.87	99.21	13.38	40.52	46.39	100.29
51	21.14	31.16	47.58	99.88	21.03	31.66	47.79	100.48
52	20.77	31.54	47.46	99.77	21.53	31.58	48.27	101.38
77	16.04	36.38	46.11	98.53	17.22	36.52	47.45	101.19
80	20.68	31.87	47.62	100.17	21.15	31.37	47.69	100.21
82a	10.89	43.28	45.91	100.08	11.28	43.51	46.45	101.24
84a	4.71	49.98	44.43	99.12	5.12	49.64	44.79	99.55
85a	1.74	53.77	44.15	99.66	1.73	53.85	44.14	99.72

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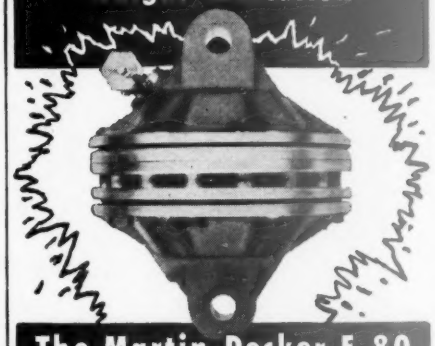

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(3) After three to five minutes the heater is started.

(4) As the carbon dioxide flows through the tube, the weight of the sample is measured at the end of each minute until the end of the experiment. The end of the analysis is reached when the temperature reaches approximately 950 C, at which time there is complete dissociation of the $CaCO_3$. This end point is sharply defined because there are no subsequent changes in the weight of the sample upon further heating.

One can easily calculate the content of $MgCO_3$ and $CaCO_3$ (expressed in per cent) from the losses in weight during each reaction.

Using the above described method, Tsvetkov and his chemist Starostina determined the chemical composition of 20 limestone samples. For comparative purposes, these samples were also analyzed by the regular wet chemical method (Table 3). These results show the accuracy of this method, in addition of being simple and rapid.

This apparatus can be rapidly assembled, occupies a very small space, and can be operated by the average laboratory technician. Although one analysis requires 30 to 40 minutes, one laboratory technician can operate two such apparatuses at the same time. By this method one operator can do 16 to 20 analyses in one working day, which is several times greater than the average output of a qualified chemist using standard technique. The time necessary for the calculations also can be shortened appreciably by using previously prepared tables giving the CaO and MgO, or $CaCO_3$ and $MgCO_3$ content from the determined values of CO_2.

The methods proposed by Tsvetkov and Berg, however, can be used only for clean varieties of carbonate rocks containing not more than 5 per cent impurities. In the case of silicified dolomites, limestones, and marls it does not give accurate quantitative results due to the reactions with the impurities. During increasing temperatures these reactions, beginning at 550 C, cause gradual loss of carbon dioxide by calcite. This gives partial over-lapping of the dissociation reactions of $MgCO_3$ and $CaCO_3$, and results in erroneous determinations.

Conclusions

There is good agreement between the results obtained by the standard wet technique and the rapid methods described in this paper. These rapid and accurate techniques will enable geologists and petroleum engineers to make the Ca/Mg ratio determination a routine analysis. In measuring the Ca/Mg ratio, however, of samples from homogeneous limestone outcrops, having a magnesium content of less than 0.6 per cent, a standard technique with double precipitation should be used. Only double precipitation will enable geologists to detect the variations in Ca/Mg ratios from bottom to top of an outcrop.

Acknowledgments

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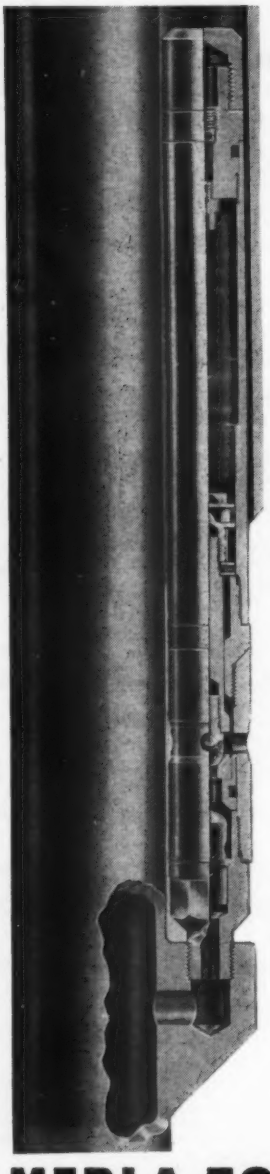

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For complete data on this new gas lift valve contact your nearest Merla representative listed below.

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LARKIN

EXCEEDS EVERY KNOWN REQUIREMENT FOR CENTRALIZER PERFORMANCE

The double-bow design of the Long Larkin Centralizer, in both the Slip-On and Lok-On Types, gives you the maximum in centralizer performance.

Based on established standards these centralizers

Take 45% less permanent set than maximum allowed*
Exert 300% more initial centering force than minimum required*

FIVE RANGES

Each of the four different types of Larkin Centralizers come in five different ranges. Therefore, there is a Larkin Centralizer "tailor made" to give maximum performance in any casing/hole size combination. The "tailor made" feature also assures easy starting at all times.

The Short Larkin Slip-On and Lok-On Centralizers fill the requirements of efficiency and economy in shallower areas or on short strings in undeviated holes.

*Certified by an independent engineering firm which tested Larkin Centralizers after an extensive survey of Oil Company standards for centralizer performance.

50th Anniversary Year

LARKIN

...Through Your Supply Store

LARKIN PACKER COMPANY, INC. • **ST. LOUIS, MO.**

Significant Discovery in Southern Oklahoma

Theory of no commercial oil in the Simpson Sand of Ardmore Basin is exploded

G. C. HALE*

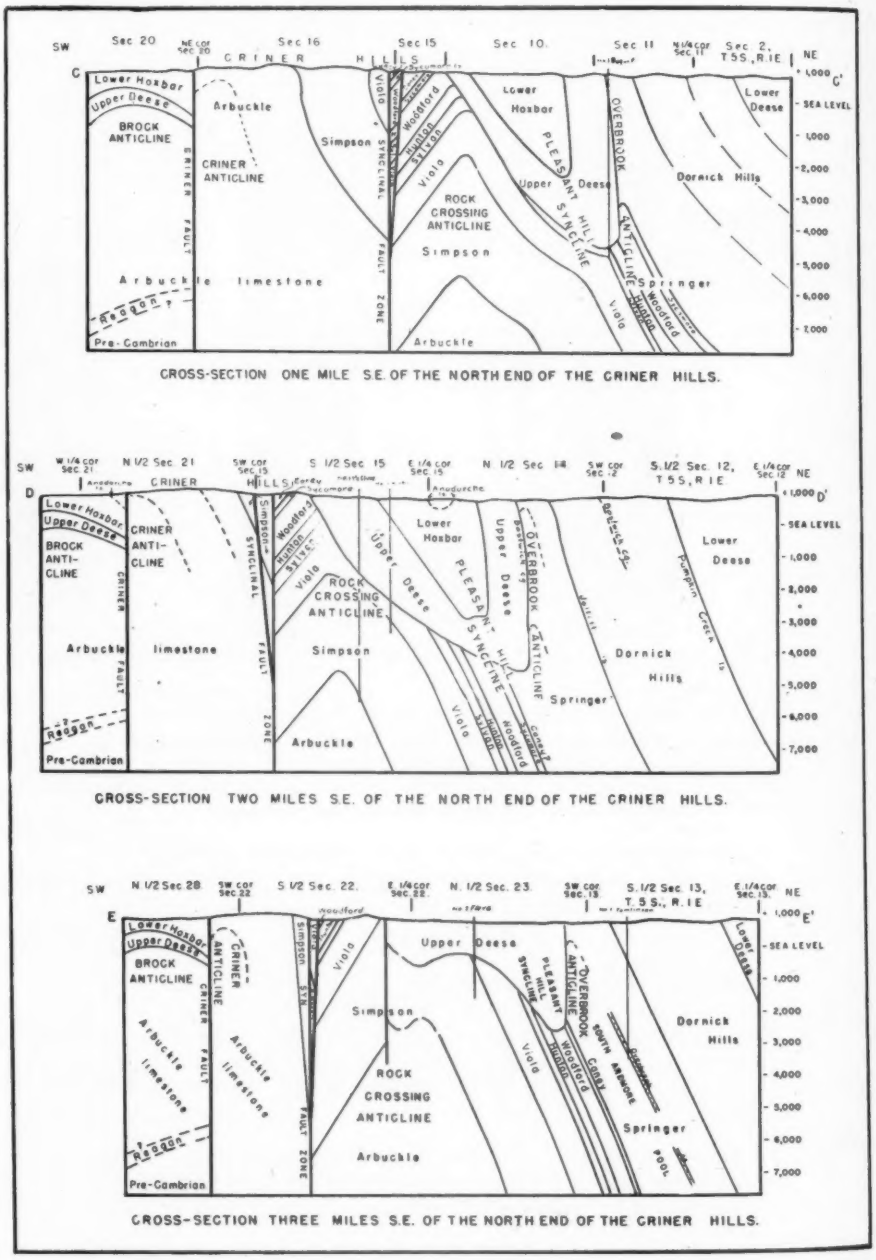
A SECOND well has been added to the recently opened Southwest Ardmore pool in Carter County, Oklahoma. The C. W. Tomlinson, et al No. 2 Farve, in the NE NE SW of Section 23, township 5 South, range 1 East, drilled to 2406 ft after encountering 42 ft of Tulip Creek sand in the interval 2017-59 ft. The Tulip Creek formation is below the Bromide and above the McLish of the Simpson Group of Ordovician age. It is sometimes called second or third Bromide. Casing has been set at 2150 ft. The No. 2 Farve, a north offset to the No. 1, is some 320 ft lower than the discovery. Cores with 60-65 deg dip, however, indicate that it was drilled somewhat along the strike, rather than the dip, of the Tulip Creek sand.

The No. 1 Farve, in the SE NE SW Section 23, township 5 South, range 1 East, made 629 bbl of 42 gravity oil in 19½ hours after recovering fracture treatment load oil. This was through perforations in the Tulip Creek sand from 1708 to 1785 ft. Core analyses indicate porosities in the range of 22 per cent.

Although the pool is expected to be small, it is probably one of the most significant discoveries in southern Oklahoma since discovery and development of the Springer sands in the middle forties. The wells virtually explode the theory of many geologists that there is no commercial oil to be found in the Simpson of the Ardmore Basin due to lack of sand development. It is true that many structures have been tested through the Simpson to find little or no oil of commercial consequence. It may well be that these tests are poorly located, structurally, and that the search for Simpson oil should be carried to the flanks of structures rather than on structural highs. Sand development is apparently the key to the search for such oil as in the Pennsylvanian of many areas throughout the Ardmore Basin and Mid-Continent.

The accompanying cross-section of the area is believed to be the best interpretation of structural conditions existing at Southwest Ardmore pool. This is a revision of an interpretation that has been studied and accepted by geologists for years.

Less than one mile west of the new wells lie the Criner Hills where every year hundreds of students from the University of Oklahoma School of Geology flock for their summer field course. * * *



*Geologist and petroleum engineer, The Gilmer Oil Company.

Hydraulically-powered rotary table in action on its first job — completion of a well working below 7000 ft with 2-in. drill pipe.

Controls are centralized on one small portable console which, in operation, is adjacent to the regular hoist operation position.

HYDRAULICALLY-POWERED ROTARY TABLE

WM. T. RINTOUL

A hydraulically-powered rotary table, believed to be the only one in use in California, has been put into operation in the San Joaquin Valley by General Production Service, Inc., of Bakersfield.

Developed by Hopper Machine Works to provide a completely independent rotary drive for conversion of well servicing units to workover jobs, the hydraulically-powered rotary table is by basic design an independent unit, capable of use with almost any portable servicing unit or under a standard derrick.

Components include a 4-cylinder diesel engine with Denison pump, which is mounted to the engine, and a Denison fluid motor mounted in the subbase and powering the 17½-in. table. Dimensions of the subbase are as follows: Height, 7 ft 10 in.; length, 20 ft, and width, 7 ft 6 in.

The power unit is mounted on a combination fuel and power oil tank, making a rigid, self-contained foundation suitable for any location. Only connection between the power unit and the subbase is the power oil and control hose system, making it possible to move the power unit to any desired location 30 ft from the end of the subbase and up to 40 ft from the center of the hole.

Power is transmitted to the rotary table through a two-speed transmission, mounted underneath the subbase. A short chain drive between the countershaft and table permits quick removal of the rotary table for setting well equipment. Any standard table can be used.

The transmission provides for selection of speeds as low as 20 rpm and as high as 200 rpm at the table so that it is possible to provide slow speed and high torque for scraping or milling operations as well as high speed for light, fast drilling.

Maximum torque in the drill pipe or tubing can be regulated from the operator's position by a remote-controlled relief valve that controls pressure at any level up to 5000 psi. Stalled torque in the drill pipe may be backed off by reducing the relief valve setting—all without stalling the diesel power unit.

The unit is completely air-controlled for all functions except starting. All controls—throttle, transmission, and operating pressure—are centralized on one small portable console which, in operation, is positioned adjacent to the regular hoist operation position.

The air throttle controls a variable speed governor.

Emergency shut-down or line failure shuts off both fuel and air supply to the engine.

By watching the system pressure gage, which indicates the torque being delivered to the drill string, the operator is able to regulate his feed.

Moving the unit requires one semi and an A-frame. The subbase, power unit, and control console are all interconnected by hose connections that do not need to be broken to set up or remove the subbase unit. The diesel unit is transported on extended skids of the main subbase and becomes part of the subbase for transportation.

EXCLUSIVE

Powered oil and control hose system — only connection between the power unit and the subbase — makes it possible to move the power unit up to 40 ft from the center of the hole.

From an economy standpoint, it is believed that the new unit will save money by giving the operator complete control of a drilling rig without the actual expense of moving in a standard drilling rig for workover jobs. Total cost of moving the unit from General Production Service, Inc.'s Bakersfield yard to its first job at Arvin was $167.34, including tanks and pump. Cost of moving a drilling rig the same distance would have been $800-$900. Additional savings are expected on a cost-per-hour basis.

From a safety standpoint, the power unit is well outside the safety radius to reduce the fire hazard.

From an efficiency standpoint, the new unit is regarded as 85 to 90 per cent efficient, i.e., that percentage of the power is delivered to the table. * *

EXPLORATION ACTIVITIES

TEXAS

★ The most northwesterly county in the Texas Panhandle has acquired its first oil or gas discovery. The Humble Oil and Refining Company's No. 1 D. D. Shelton, in northeastern Dallam County, has been reported as flowing gas rated at 8,000,000 cu ft daily. Well is producing from the Cisco from perforations at 3564-82 ft and 3624-94 ft.

★ Ada Oil Company has made a Pennsylvania gas discovery 14 miles southeast of San Angelo, Tom Green County. The well, No. 1 J. M. Willis Johnson, produced 1,940,000 cu ft of gas a day. The well is producing through perforations between 4678-90 ft and 4698-708 ft.

★ Sinclair Oil and Gas Company's No. 1 E. F. Thompson has opened Rodessa production in Smith County. Well pumped 133 bbl of 42 gravity oil daily from perforations at 7254-66 ft.

★ Tide Water Associated Oil Company's No. 1-D Campbell Unit in Franklin County has found production in the Smackover. Well tested 1,551,000 cu ft of gas plus 165 bbl of distillate per million from holes at 11,998 to 12,356 ft after acidizing.

★ O. K. Smith Drilling Company apparently has a dual gas discovery in San Patricio County. Well tested gas and distillate through ¼-in. choke from 4416-24 ft and 5680-88 ft under respective pressures of 1600 and 1700 lb.

★ Gulf Oil Corporation's No. 1 Scharbauer Cattle Company "L" has tested the Ellenburger at 12,714 ft. Test recovered 238,000 cu ft of gas. In 6 hours, 34½ bbl of 45.8 gravity oil was recovered.

Well previously found pay in the Simpson section at 12,615 ft.

★ Midwest Oil Corporation's No. 1 M. F. Guetersloh flowed 365 bbl of oil daily on 14/64-in. choke from perforations at 8846-64 ft. Oil was of 42.5 gravity and the gas-oil ratio was 748 to 1.

WYOMING

★ Stanolind Oil and Gas Company and Associates' No. 1 Sherwood Unit, A Natrona County wildcat, has indicated a new oil discovery as the result of recovery of free oil on a drillstem test in the Muddy sand. The test, of unreported time, was from 10,747 to 10,773 ft and had a show of gas estimated at 555,000 cu ft daily with 135 ft of light green oil. Prospective discovery was on a unit of 3865 acres of which Stanolind owns 2769 acres.

★ Mobil Producing has reported an apparent Frontier gas discovery on the Skelton Dome Unit, Hot Springs County. Operator tested gas at the rate of 1,500,000 cu ft. Well is 2 miles southeast of a previous failure by operator.

★Shell Oil Company has announced the completion of its No. 1 Hallworth well, a South Ash Creek discovery in Sheridan County. Well pumped 260 bbl of 35 gravity oil per day. It was drilled to a total depth of 4960 ft, plugged back to 4923 ft and perforated in the intervals 4886 to 4902 ft and 4907 to 4918 ft.

Summary of drilling activity for September
(As compiled by Rinehart Oil News Staff)

States	New locations		Wildcat completions			Field completions			Junked & abnd		Temp. abandoned		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	6	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0
Arizona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Arkansas	14	55	0	0	14	43	1	13	2	0	0	0	0	3	13	18
Canada (Williston B.)	39	47	0	0	24	28	0	2	1	0	0	2	0	0	25	18
Colorado	75	54	4	1	60	28	3	15	0	0	2	0	2	1	59	45
Florida	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kansas	62	273	12	4	56	144	17	71	0	0	0	0	2	2	68	294
Louisiana	47	335	3	2	33	230	35	60	1	2	0	5	1	6	63	231
North	31	208	0	0	21	169	14	31	0	2	0	0	0	4	18	43
South	16	127	3	2	12	61	21	29	1	0	0	5	1	2	45	188
Mississippi	18	27	2	1	11	11	1	6	1	0	0	0	0	0	18	40
Montana	19	20	0	0	12	9	0	6	0	0	0	1	5	0	24	27
East	2	8	0	0	5	3	0	0	0	0	0	1	5	0	7	9
West	17	12	0	0	7	6	0	6	0	0	0	0	0	0	17	18
North Dakota	11	11	0	0	11	11	0	0	0	0	1	0	0	0	13	21
Nebraska	17	31	10	0	12	30	0	7	0	0	0	0	2	0	18	27
Nevada	2	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0
New Mexico	20	91	2	1	11	50	47	5	0	0	6	3	0	1	45	122
Eastern	15	71	2	1	8	49	8	4	0	0	0	0	0	0	34	84
San Juan	5	20	0	0	3	1	39	1	0	0	6	3	0	1	11	38
Oklahoma	69	665	11	1	79	457	40	176	2	3	4	10	5	22	63	587
South Dakota	2	0	0	0	5	0	0	0	0	0	0	0	0	0	2	0
Texas	485	1284	62	23	364	822	84	234	2	3	7	19	10	46	396	865
East	30	77	1	1	24	30	10	13	0	0	0	0	2	11	22	122
Gulf Coast	48	134	2	6	42	73	10	10	1	1	1	7	0	3	42	91
North Texas	86	265	12	2	50	129	6	75	0	0	0	0	0	0	47	83
Panhandle	5	47	3	1	4	41	21	4	0	1	0	0	1	0	18	23*
South Texas	103	217	5	9	88	118	31	42	0	1	2	2	1	3	68	98
Border Co.	34	79	11	0	19	57	0	13	0	0	0	0	1	4	23	63
West Central	114	151	12	2	76	69	1	46	0	0	2	7	2	4	62	68
West Texas	65	314	16	2	61	305	5	31	1	0	2	3	3	21	114	317
Utah	9	3	0	0	6	0	2	4	1	0	2	0	0	0	29	9
Wyoming	21	43	1	5	11	44	2	9	0	0	0	0	0	1	55	101
Totals: Jan.	699	2425	121	47	611	1780	254	584	6	5	10	21	17	144	808	2359
Feb.	713	2816	101	28	503	1583	228	542	0	5	21	22	29	98	845	2362
Mar.	975	2945	115	42	585	1866	242	605	0	6	27	33	16	69	950	2659
April	966	3166	117	46	665	2006	186	618	2	4	20	24	25	108	953	2665
May	879	2727	92	35	600	1762	170	478	2	2	29	21	13	92	945	2580
June	1074	2978	110	42	704	1759	250	524	4	2	36	59	35	113	1008	2640
July	1018	2940	132	42	727	2059	255	666	5	4	15	40	14	117	936	2361
Aug.	887	2880	111	38	734	1848	226	616	0	5	17	20	31	83	872	2349
Sept.	916	2940	107	38	715	1907	232	608	1	8	23	40	27	82	902	2406
1954 Total	8127	25,817	1006	358	5844	16,570	2043	5241	30	41	198	280	207	906	—	—

*Figure incomplete

Courtesy Rinehart Oil Reports

MISSISSIPPI

★ W. C. Feazel and associates have completed a small gas well, No. 1 Rea, 10 miles southeast of Aberdeen, in southeastern Monroe County. Well is an abandoned wildcat, which had been drilled to the Devonian. It is producing from the Carter sand from perforations at 3360-69 ft. On test, through a ⅛-in choke, well produced 2,150,000 cu ft of gas a day. Well is the only new field this year in the Basin.

Discovery is 4 miles northeast of Hamilton, for which the field was named, and 1 5miles from nearest production.

OKLAHOMA

★ R. G. Woods No. 1 Pipestem, a wildcat in sw sw ne of 19-23n-2e, has obtained production from the Skinner sand at a depth of 3900-08 ft. The well flowed 5 bbl of oil an hour.

★ Gulf Oil Corporation's No. 1 Costell seemingly has a Bromide sand discovery in Grady County. Drillstem test from 11,747 to 11,797 ft yielded 88 bbl of oil through ½-in. choke.

★ The Golden Trend area has been extended by Vickers Petroleum Company with its No. 2 Crossland. Upon completion the well flowed 372 bbl of oil in 24 hr through choke. Production is from the Springer sand at 9752-86 ft.

★ Vickers Exploration Company's No. 1 Sunray-Crawford, Garvin County, flowed 400 bbl of oil in 24 hours through a 22/64-in. choke. Flow was from Springer sand perforations 9880 to 9910 ft with tubing pressure of 150 lb.

★ Sohio Petroleum Company's No. 1 First State Bank is testing after flowing 223½ bbl of oil in 17 hours through a 13/64-in. choke with a gas-oil ratio of 797 to 1. Well is producing from perforations in the McLish.

XUM

... now comes the BIG QUESTION

You've reached potential pay and cored the section. Now comes the big question – *pay out or play out?* . . . After thousands of dollars and months of effort have been spent to accumulate acreage, drill an exploratory well, and core a probable productive formation, sound business practice demands *good core analyses* . . . and the reliability of these data can be assured by the experience and technical background of the organization performing the work . . . If your best efforts deserve the best possible answer, take advantage of Core Lab's eighteen years' experience in all active areas.

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Exploration

NORTH DAKOTA

★ A new oil field has been found in Williams County by the Western Nodana Oil Company and Paul Rutledge. The discovery well, No. 1 Westberg, is six miles west of the Tioga district. Production is from the Madison lime at 8135-44 ft, with the initial flow 425 bbl a day. The Westberg well is about a mile from the McGregor pool, which has 2 small marginal producers, and this may be a more prolific pay section of the same reservoir.

★ Stanolind Oil and Gas Company will be the operator on a 13,500 ft wildcat tentatively located in Dunn County. Wildcat is to be a joint venture of Carter Oil Company, Cities Service Oil Company, Mobil Producing Company, and Sinclair.

PERU

★ The Douglas Oil Company's Peruvian subsidiary has reported its second discovery. The well, 2 miles northwest of the company's first strike, had a 90-bbl-a-day flow of 38 deg oil through a ¼-in. choke from 3266 ft. A 5000-ft wildcat is planned ½ mile offshore from the second producer.

★ Compania Petrolera Lobitos, which offsets the Douglas concession, has reported a second discovery. Well made 530 bbl of 39 deg oil.

COLORADO

★ The discovery of a new oil field by Lion Oil Company has been announced. Discovery well was drilled on a block of about 4000 acres in north central Colorado's Jackson County. The successful wildcat is known as the Dwinnell No. 1, but the field has not been officially named. At a depth of 4626 ft, in 35 ft of good porosity Lakota sandstone, the well flowed 32-gravity oil on drillstem test.

★ Wytex Service Company and Rex Monohan have recovered 1200 ft of oil and 240 ft of heavily oil-cut mud on a test at Forbes in Washington County. Well is about 5 miles east of the McRae field.

★ British-American Oil Producing Company has reported its No. 1 Hegarty completed for 235 bbl of oil per day. Well is producing from the D sand and is now shut in for storage. The new field is in Morgan County.

LOUISIANA

★ Shell Oil Company has opened a gas-distillate pool 3 miles southwest of the Sullivan's Lake field in Iberville Parish. The well, No. 1 Schwing Lumber Company tested 2,123,100 cu ft of gas plus 63 bbl of 52.6 gravity distillate daily through a 9/64-in. choke. Test was from 10,974 to 10,980 ft. Gas-liquid ratio was 33,700 to 1.

★ Tide Water Associated Oil Company's wildcat on the northwest flank of the Venice dome in Plaquemines Parish has logged 2 potential pay sands below 14,000 ft. The well, No. 2-E Manhattan Land and Fruit Company had a 13-ft section at 14,260-87 ft and a 6-ft section at 14,377-83 ft.

MONTANA

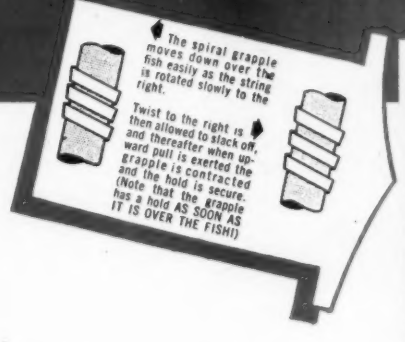
★ A new gas field in the Hailstone Dome-Big Coulee area of Golden Valley has been opened by Northern Natural Gas Producing Company. A gage of 6,700,000 cu ft per day was reported. Production is from the Morrison. Well was drilled to total depth of 2145 ft.

★ Shell Oil Company has completed its No. 14-34 Unit for a new field discovery in Fallon County. Well pumped 209 bbl of oil from the Red River between 8202 and 8319 ft.

★ J. H. McDermott has announced completion of his discovery well in the Clark Fork area of southern Carbon County. Well flowed 248 bbl of 43 gravity oil through a ¼-in. choke from perforations in the basal Frontier, 6713-6731 ft and 6736-6749 ft.

★ Amerada, with other companies aiding, is planning a wildcat on the Pawlowski ranch in extreme western McCone County. Nearest production is in Shell's Southwest Richey field about 24 miles to the southwest.

"GrappleGrip" OF BOWEN OVERSHOT CATCHES FISH EASIER!


The spiral grapple moves down over the fish easily as the string is rotated slowly to the right.
Twist to the right is then allowed to slack off, and thereafter when upward pull is exerted the grapple is contracted and the hold is secure. (Note that the grapple has a hold AS SOON AS IT IS OVER THE FISH!)

Holds Tighter as Load Increases!

In today's fishing jobs, you can't take chances on weak-kneed tools. It is imperative that you get the pipe out of the hole quickly and safely without further equipment losses!

And when you have a job for an overshot, there's one way to make sure that you get a rock-solid grip every time—a grip that cinches tighter as pull increases. ORDER OUT A BOWEN RELEASING OVERSHOT!

NO SLIPS TO CHANGE . . . NO ADJUSTMENTS

Without changing slips or making any adjustment whatever, this tool catches drill pipe, coupling, or tool joint—whichever is up! As soon as it's over the fish, the spiral grapple takes hold with a full-length crush-proof grip that tightens as pull increases.

An integral milling member rounds up any ragged ends of the fish, and a guide on bottom gets the tool over the fish. Although made with minimum outside diameter for use under tight hole conditions, the Bowen Overshot nevertheless withstands the hardest pulling or jarring operation. And release from the fish, if necessary, is a simple matter of a downward bump, a turn to the right and simultaneous upward movement. It both sets and releases—TO THE RIGHT!

One to as many as four-bowl Overshots can be supplied in the size you need for any job.

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CALIFORNIA

★ Monterey Oil Company has discovered an offshore oil field in the submerged lands of California with the completion of Monterey-Texas State No. 3, located some 8000 ft seaward from the City of Seal Beach and 4½ miles southeast of the Wilmington oil field.

Well was drilled from an island location to a total depth of 10,162 ft. It was plugged back and completed with 7-in. casing set at 5906 ft, with an interval from there to 6280 ft opened to production. A second well, Monterey-Texas State No. 4, has been spudded from the island location.

★ Seaboard Oil Company is preparing to spud a wildcat 2 miles east of Kettleman City on the edge of Tulare Lake. The well, Gibson No. 22G-22, will look for gas production between 4000 to 5000 ft.

★ Humble Oil and Refining Company has moved in to drill a new gas test about 4 miles northeast of production in the Beehive field. Site of the test is on the Parrot Investment Company lease in Butte County. Well will be Parrot Investment Company No. 1.

NEW MEXICO

★ Lawton Oil Corporation's No. 1-B Brady Lowe, a wildcat 1½ miles south of Wolfcamp production in Lea County's Gladiola pool, recovered 1500 ft of oil and 30 ft of slightly oil and gas-cut salt water at 9752-66 ft.

★ Stanolind Oil and Gas Company has tested a lower Wolfcamp oil discovery in southwestern Lea County, 3 miles north of the Tonto pool. The well, No. 1 Buffalo Unit, pumped 117 bbl of oil and 5 bbl of water in 24 hours from perforations at 10,597 to 10,620 ft.

CANADA

★ Seaboard-Canadian Superior's Hillsdown 14-17 has been completed in the D2 Devonian formation. Well flowed 668 bbl of 38 deg oil through a 35/64-in. choke. Well is 5 miles east of Red Deer and 4 miles west of the Joffre Viking oil field. Production is from intervals 7188 to 7204 ft.

★ Bailey-Selburn Oil and Gas, Ltd., has reported a test on a new gas well in the 12 mile Creek area. It showed an estimated open flow of 10,000,000 cu ft a day. Well is on a 17,000-acre tract and 15 miles from the projected pipe line that would provide transportation for gas to market in eastern Canada.

★ Oilwell Operators, Ltd. operating company of Home Oil Company, Ltd., and Federated Petroleums, Ltd., has reported a discovery well 15 miles northeast of Pembina field. Well indicated an initial potential of nearly 100 bbl of 38 gravity oil daily.

UTAH

★ Carter Oil Company has tested commercial gas shows at it's No. 2 Unit, a wildcat in the Blue Bell area of Duchesne County. A test of the zone between 7875 and 7915 ft flowed gas at the rate of 5,000,000 cu ft daily. Well also recovered 147 ft of 42 gravity oil and 147 ft of gas cut mud.

MEXICO

★ Discovery of a new oil field in Mexico has been announced by Asolfo Ruis Cortines, president of Mexico, Pemex, the government oil agency, drilled the well near Texulutla on the Gulf Coast. Well flowed 3000 bbl of oil daily through a ½-in. choke. Oil was described as 30 gravity with a paraffin base, the lightest ever found in Mexico.

KANSAS

★ The completion of Stanolind Oil and Gas Company's No. 1 Scott, opening the Hixson-East field in Trego County, has been reported by the Kansas Conservation Division of the State Corporation Commission.

Located one and one-half miles east of the Hixson field, well was rated at 39 bbl daily paying through perforations in Marmaton rocks from 3844 to 3854 ft.

★ Sinclair Oil and Gas Company has opened a new gas-distillate pool 12 miles north of the Oklahoma state line in Clark County, Kansas. The well, No. 1 Combrink, tested the Morrow sand between 5318 and 5335 ft for a gas flow of 7,000,000 cu ft daily. Sixty feet of heavily distillate-cut mud was also recovered.

★ Deep Rock Oil Corporation's No. 1 Bowker has opened a new field that is yet to be named. Well is producing from Lansing-Kansas City perforations at 3821 to 3826 ft and is rated at 135 bbl daily.

NEBRASKA

★ Ryan-Davis Oil Company has completed its No. 1 Itner, a Cheyenne County discovery well. Well pumped 386 bbl of oil daily from the J sand between 5384 and 5394 ft.

★ Gem Oil Company has completed its No. 1 Woten, Cheyenne County, pumping 140 bbl of oil per day. Production is from the J sand from perforations at 5444 to 5457 ft. A confirmation well has been started.

ARKANSAS

★ Critchell Parsons and John C. Robbin's No. 1 Wilson heirs has reported a dry gas show. Well is a rank wildcat in Scott County northwest of Waldron. Top of the gas sand was at 2440 ft. Sand is believed to be the Atoka series.

PUMPING PROBLEM

REDA

MAY HAVE THE RIGHT ANSWER

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WHAT'S DOING IN DRILLING

NEBRASKA

★ Bishop Oil Company announces today its Torgeson No. 3 well on a 160-acre lease in Kimball County, has been completed to production and is producing at the rate of 140 bbl a day. Present allowable is 100 bbl daily. Bishop has two other producing wells on the lease, each with the same allowable. Total depth of the new well is 6540 ft. Oil is 38 gravity. Bishop's interest is 50 per cent, the remaining half interest belonging to Nebraska Drillers, Inc.

TEXAS

★ Completion of the Forest-Cities Service Dora Roberts B-1 No. 1 test for a potential of 1417 bbl of oil daily forges another significant link in the chain of Ellenburger discoveries that extend almost 14 miles southeastward from the Headlee field of Ector County and across the east side of the nine-mile long Dora Roberts ranch of Midland County. First of the Ellenburger discoveries on the 20,000-acre Dora Roberts ranch was at the Dora Roberts C-4 No. 1. Next link in the chain was the Cities Service Parks No. 1 discovery, offsetting the Roberts ranch and midway up its eastern boundary. This discovery was completed for an initial of 3320 bbl daily.

Latest link in the discovery chain is in the northeastern corner of the Roberst Ranch. Well made 354 bbl of oil in 6 hours through 1-in. choke from 12,835 to 13,012 ft.

★ Cities Service Oil Company's No. 2-C Shannon has been completed, in the West field, Crockett County, for a calculated daily flowing potential of 1576 bbl of 42.6 deg oil with a gas-oil ratio of 1694 to 1. Well is producing from perforations from 8076-178 ft.

★ Continental Oil Company has completed its McCollum and Wiebusch No. 8 and 9 in the Wemac field of Andrews County. The No. 8 flowed 1800 bbl of 50.3 deg oil daily and 228,000 cu ft of gas a day through ¾-in. choke. Flow was from 13,298 to 13,348 ft in the Ellenburger. Gas-oil ratio was 127-1.

No. 9 was perforated from 13,302 to 13,352 ft in the Ellenburger. On potential test, it flowed 1886 bbl of 49.5 deg oil and 789,000 cu ft of gas daily through a ¾-in. choke. Gas-oil ratio was 418 to 1.

★ Humble Oil and Refining Company's No. 1 Henry Halff estate, a southeast extension to Amaker-Teppett field in central Upton County, has been assured of Wolfcamp pay on the basis of a drillstem test. Testing at 8970-95 ft, well gaged 30 bbl of 43.5 gravity oil in 1 hour on a ½-in. choke and 50.67 bbl in 1 hour and 25 minutes through a 1-in. choke. Gas-oil ratio was 1014 cu ft. Flowing pressure ranged from 960 to 1830 psi and 65-minute shut-in pressure reached 2330 psi.

★ Ralph Lowe's No. 1 Humble-King, in the Deep Rock-Ellenburger pool of Andrews County, flowed 594 bbl of oil in 6 hours and was given a daily potential of 2376 bbl. Choke size was 1-in. and the pay section was open hole from 12,147 to 12,235 ft. Well is the third producer in the field and was originally drilled dry to 5828 ft.

CALIFORNIA

★ A new oil well flowing at a rate of 1107 bbl a day has been completed by Tide Water Associated Oil Company. The well, located on the company's Lloyd Lease in the Ventura Avenue field, is Lloyd No. 167. It produced 33.0-deg gravity oil from a depth of 12,900 ft in the D-8 zone through a 14/64-in. bean along with 932,000 cu ft of gas daily. It is nearly 1 mile east of the nearest D-8 zone well on the Lloyd Lease.

★ In the McKittrick area of Kern County, Tide Water's Northwest Belgian Anticline No. 84-16 is flowing 367 net bbl of 38.5 gravity oil and 120 MCF of gas daily through an 18-64-in. bean from a depth of 3,088 ft. This well is the first drilled by Tide Water on its land in this area.

★ Union Oil Company has completed two more producing wells on its extensive holdings in the La Habra Heights area of Los Angeles County. Sansinena 8B-11 is flowing 420 bbl a day of 26.8 deg gravity crude and No. 9A-8 is pumping 250 bbl per day of 29.3 deg gravity oil. Both wells are in the eastern portion of the property.

OKLAHOMA

★ E. L. Oliver has completed No. 2 Kreig in Lincoln County, flowing 60 bbl in 15 hr through a 13/64-in. choke. The producing zone is in the Checkerboard sand at a depth of 3803-15 ft. Gravity of the oil is 52 deg and the gas-oil ratio 800 to 1.

★ Altus Drilling and Dillon Oil Corporation's No. 3 Laird tested 25,000,000 cu ft of gas a day on a 1-hour drillstem test in the Sycamore from 4538 to 4642 ft. Well is an apparent confirmation of the company's No. 2 Laird, a gas discovery in the Velma pool of Stephens County.

★ Vickers Petroleum Company, Inc's., No. 1 Sturm, in Stephens County, made 440 bbl of oil through various chokes on initial 11-hour test of Burkhart perforations at 5246-52 ft. Well flowed 60 bbl of oil an hour through a 40/64-in. choke and 4 bbl on 20/64-in. choke.

★ Cities Service has located a test well in the center of the NE NE Sec. 17-4N-4W, Garvin County. The well, McCoy No. 1, is 2½ miles east of the Bradley-Springer sandstone pool 1¼ miles northwest of the Purdy Springer pool. Objectives of the test are the Hart and Springer sandstones with an expected total depth of 9100 ft.

MONTANA

★ Continental Oil Company has completed Kincheloe "A" No. 4, in the Sumatra field, Rosebud County. Perforated in the Heath sand from 4650 to 4600 and from 4664 to 4670, well had a pumping initial of 195 bbl of clean oil daily. This is fourth consecutive producer in this area for the company, which has commenced its fifth well on this same lease.

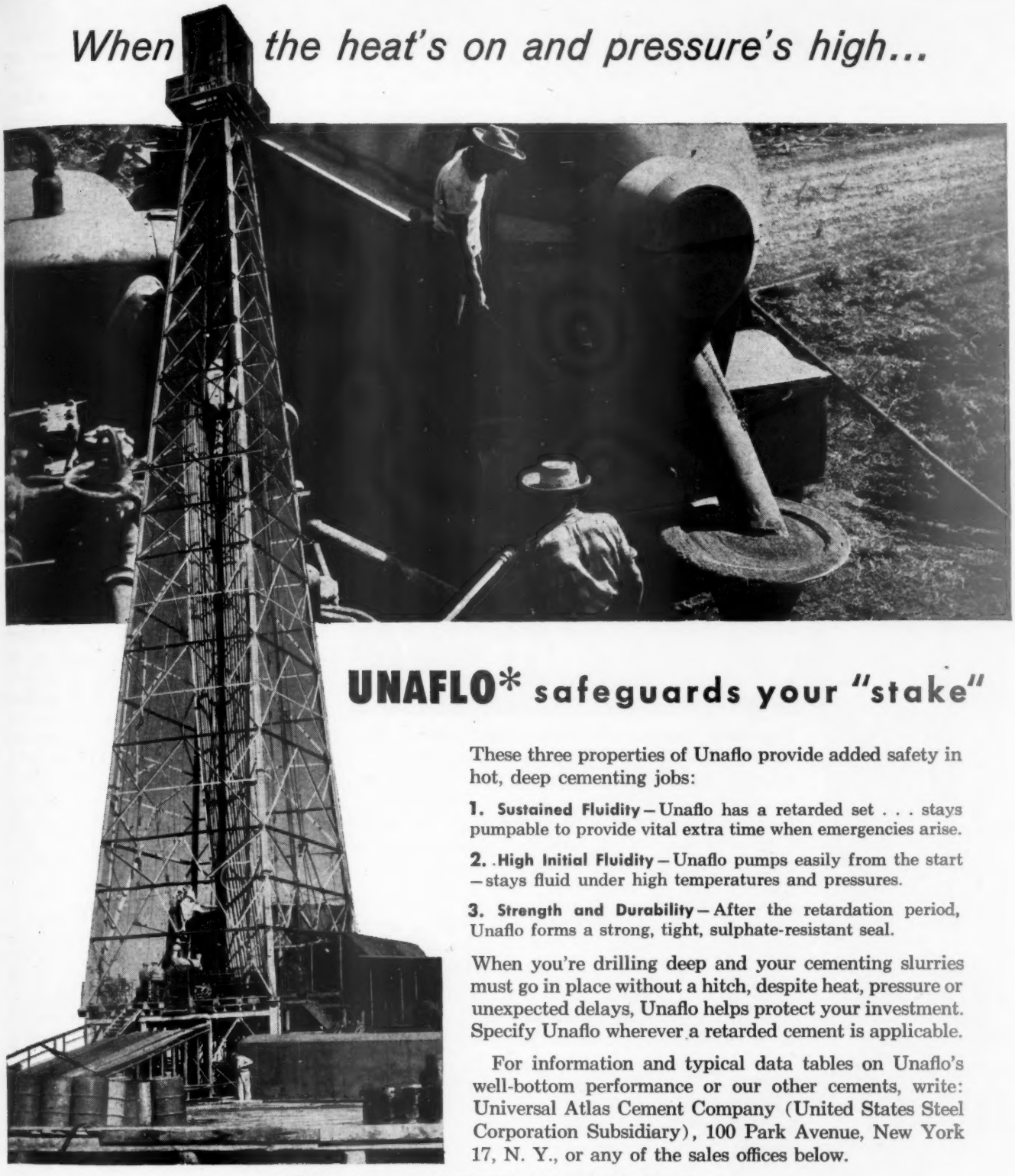
★ M. K. M. Oil Company is coring the Bannatyne field pay zone in its No. 1 Skoog, Pondera County. If cores show up favorably, oil zone will probably be sand fraced.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Sept. 20	Sept. 27	Oct. 4	Oct. 11	Oct. 18
Pacific Coast	126	128	132	132	128
Oklahoma	282	276	268	294	300
Kansas	164	163	154	139	162
Rocky Mountains	245	250	258	245	250
Canada	121	120	135	146	151
Ark-La-Tex	187	185	172	165	171
West Texas and New Mexico	440	439	452	452	447
Gulf Coast	513	491	494	503	523
Illinois	148	125	148	151	142
North Texas	293	290	286	280	287
Total	2519	2467	2499	2507	2561

*As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

When the heat's on and pressure's high...



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Drilling

LOUISIANA

★ Union Oil Company is actively developing its leases in the East Lake Palourde field, in Assumption Parish, discovered by the company early this year. It has just completed its third oil producer in the field, Williams No. 5, which came in flowing at a daily rate of 267 bbl of 40-deg crude. Well's potential is much higher than this rate indicates, as flow is through 8/64-in. bean, with 2800-psi tubing pressure.

★ Union Sulfur and Oil Corporation, Houston, Texas, has extended the Lake Arthur (North) salt dome field of Jefferson Davis Parish. A deep sand pay extends the field 3000 ft to the northwest. The well, TRS Farms No. 10, flowed at the daily rate of 3,300,000 cu ft of gas and 70 bbl of 48.6 gravity distillate on a drillstem test through 12/64-in. choke and perforations at 10,744-82 in 83 ft of Marginulina Texana sand. Tubing pressure was 3800 lb.

★ Continental Oil Company's No. 2-B Jeanerette Lumber and Shingle Company has tapped a third horizon in the Bayou Long field, gaging 2,103,000 cu ft of gas with 54 bbl of distillate daily through 10/64-in. choke and holes at 12,366-76 ft.

★ Richardson and Bass No. 2 Cal-Nat Unit B flowed 194 bbl of 32 gravity oil daily through 8/64-in. choke and holes at 10,402-17 ft to confirm production in the new extension area of the Little Lake field.

CANADA

★ Hudson's Bay Oil and Gas Company, Ltd., Amurex Oil Development Company, and Richfield Oil Corporation of California have found sizable flows of gas along with some distillate in the companies' Hespero area extension. The well, No. 1632 Medin is ¾ of a mile from the teams 1-2 Medin discovery. Production was found in the Mississippian and D2 formations but the new production is in the D3. First test was run of interval 8880 to 8893 ft. Well recovered an estimated 10,000,000 cu ft of gas and 180 ft of dark green to black condensate.

MICHIGAN

★ Miami Operating Company, Inc's No. 4 Hope, a Cranberry Lake Field well, has found pay in the third Traverse formation. Well flowed as much as 20 bbl of oil an hour on test and was estimated good for 500 bbl a day natural. This is the first well definitely known to be producing from the so-called third Traverse pay. Most wells in the Cranberry Lake field produce from the Richfield formaton.

★ Union Development Company has tested a well in Prosper Dundee pool, Missaukee County. The well, No. 1 Merrill-Palmer School, was showing for about 60 bbl of oil a day from the Richfield after acidizing with 4000 gal. Pay zone was from 5128 to 5143 ft.

ARKANSAS

★ Arthur Richenthal No. 1 Moore has extended the Kiblah field in Lafayette County. Well flowed 200 bbl of oil daily through ¼-in. choke from perforations at 6001-06 ft in the Mitchell sand. A north offset to the extension is underway.

BRITISH COLUMBIA

★ Pacific Petroleums, Ltd., has completed a gas well with an estimated open flow potential of 44,000,000 cu ft daily. Well is in the West Buick Creek gas field.

NORTH DAKOTA

★ Amerada Petroleum Corporation's No. 2 Viall, in the Hofflund pool of Williams County, has been completed for an initial output of 242 bbl of 42 deg oil. Oil flowed through 14/64-in. choke and registered 600 lb tubing pressure. Gas-oil ratio was 1059 to 1. The well was directionally drilled under a reservoir formed by construction of dam across the Missouri River.

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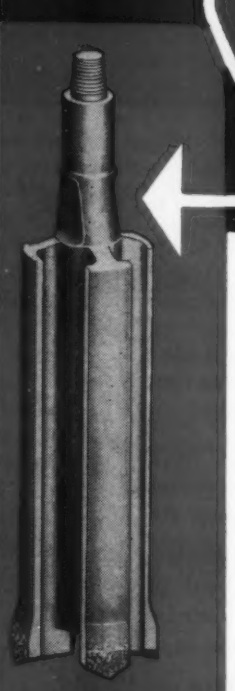

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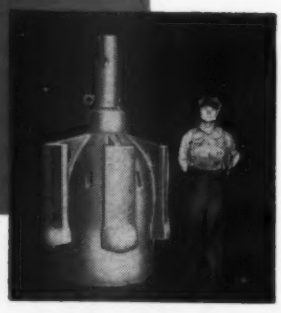
For detailed information on SPANG Fabricated STAR BITS and SPANG PILOT-TYPE REAMER BITS for big hole drilling, plus 52 page CATALOG, consult your nearest SPANG DEALER or write direct to



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OKLAHOMA

★ Manahan Oil Company has opened a new producing zone in the West Garrett pool of Kay County. No. 1 Nowman, drilled to 3702-20 ft in the Skinner sand, pumped 71 bbl of oil a day. The field also produces from the Wilcox and Cleveland sands.

★ Oras A. Shaw has brought in a large producer in the West Little Chief pool of Osage County. No. 3 Firrell-Weyl, flowed 83 bbl of oil an hr. Production is from the Burbank sand at 2894-2940-ft.

★ Stanolind Oil and Gas Company's No. 2 Crawford, in Garvin County, flowed 352 bbl of oil in 24 hours through a 28/64-in. choke from Hart sand perforations. Tubing pressure was 100 lb. Well was drilled to TD of 9900 ft and plugged back to 9800 ft.

BORNEO

★ An extension to the Seria oil field has been made by British oilmen one mile offshore in the South China Sea. The British Malayan Petroleum Company is currently building two offshore drilling platforms in an attempt to fix the pool's limits.

NEW MEXICO

★ Cities Service Oil Company has reported completion of 2 wells in Chaves County. Company's Government B No. 9 was finaled at a total depth of 3063 ft in anhydrite. Well pumped 160 bbl of 37 deg of oil in 24 hours. Government B No. 12 was completed at 3063 ft in anhydrite. It pumped 126 bbl of 41 deg oil in 24 hours.

WYOMING

★ The Sinclair Oil and Gas Company has dually completed its No. 30 Happy Springs unit in Fremont County. The well swabbed 282 bbl of 39.3 deg oil in 18 hours from perforations in the Lakota and 175 bbl of 32.3 deg oil in 24 hours from the Phosphoria.

★ Sapphire Petroleum Limited reports drilling in progress on 5 additional wells on the approximately 20,000 acres of leases it recently acquired in Wyoming's Powder River Basin. These 5 wells are in addition to 5 other wells the company drilled and successfully completed as producers since it acquired the properties in August. There were 61 producers on the properties at the time of the purchase.

Penrod Drilling Company offshore drilling support being built by the Levingston Shipbuilding Company at Orange, Texas. Support will be 220 ft long, 72 ft wide, and 40 ft deep and will be used in conjunction with offshore operations.

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RUNNING TOUR with MEN in the INDUSTRY

E. R. Senac, former district engineer for Tide Water Associate Oil Company, has been promoted to assistant district production superintendent of the Lafayette, Louisiana, district. **W. E. Grolemund** was promoted to area production superintendent at Houma, Louisiana.

L. D. Lott has been advanced to district production superintendent at Victoria. Texas. **A. G. Metcalfe** was promoted to area engineer at Conroe, Texas, **W. C. Pfister** has been promoted to district engineer at Lafayette. **J. C. Broom** has been promoted area engineer at Venice, Louisiana.

Paul Schultz has been elected president of Blackwell Oil and Gas Company. Schultz was manager of the former Carthage Hydrocol chemical plants acquired by Stanolind Oil and Gas Company.

Harold F. Parsons has been retained as east coast representative of the natural gasoline sales division of Warren Petroleum Corporation. Parsons will also be associated with Petroleum Exchange Corporation.

John S. Crews, formerly with The Pure Oil Company and Amerada Petroleum Corporation is now a research geologist for Arabian American Oil Company.

Ira Brinkerhoff and **Ralph H. Cummins** have announced the dissolution of their partnership. Brinkerhoff will continue consulting in the San Jacinto Building, Houston, Texas. Cummins will operate as Ralph H. Cummins, Inc., with offices in the Fort Worth National Bank Building, Fort Worth, Texas and the Texas State Hotel, Houston, Texas.

D. M. West, district geologist for Socony-Vacuum Oil Company of Canada, Ltd., has been transferred to Edmonton as district geologist for the company's central Alberta district. **A. R. Neilson** has replaced West as district geologist at Regina.

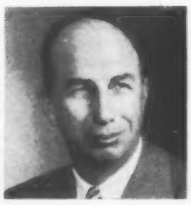
L. Claude Roark and **Park G. Ogden, Jr.,** have been appointed to the geological staff of Buffalo Oil Company. Roark will become geologist in charge of the Tulsa, Oklahoma, exploration offices and Ogden will hold the same post at Lafayette, Louisiana. Roark, former district geologist for Sinclair Oil and Gas Company, is a graduate of the University of Oklahoma. Ogden had been employed since 1948 as an exploration geologist in southern Louisiana for Stanolind Oil and Gas Company. He is a graduate of Ohio State.

O. V. Henry

W. J. Yost

J. D. Anderson

J. R. Grimes, Jr.



G. F. Bish

R. E. McMillen

J. S. Leonard

W. B. Emery has been named director and vice president of The Ohio Oil Company's production department. **F. E. Smith,** assistant manager of production, has been appointed manager of production and elected a vice president. **G. F. Bish,** division manager at Tulsa, Oklahoma, and **G. F. Poe,** general superintendent of production, have been appointed assistant managers of production with headquarters at the general office.

E. B. Stewart, division manager at Terre Haute, Indiana, will succeed Bish as manager of the Tulsa division. **J. D. Anderson,** assistant division manager at Houston, Texas, will move to Terre Haute as division manager. **I. G. Burrell,** assistant to the manager of production at Findlay, has been appointed assistant division manager of the Houston division. **O. V. Henry,** division superintendent of production at Houston, succeeds Poe. **J. A. Grimes, Jr.,** assistant Houston division superintendent of production, advances to division superintendent.

Smith has been associated with the company for 40 years. His first job was as office boy in Marshall, Illinois. He was named assistant manager of the production department in 1950.

Bish began with Ohio Oil as a roustabout at Haynesville, Louisiana in 1923. He was named Tulsa division manager in 1944.

Stewart is a 40-year veteran of the oil business. Formerly district production manager at Sidney, Nebraska, Stewart was made Terre Haute manager in 1953.

Anderson, a graduate of the University of Wyoming, worked for the Wyoming Highway Department before joining Ohio in 1937. In 1948 he was made manager of the purchasing department headquartering in Findlay and held that post until 1952 when he was appointed assistant manager of the Houston division.

Burrell joined The Ohio Oil Company following his graduation from the Colorado School of Mines in 1931. His first

F. E. Smith

E. B. Stewart

I. G. Burrell

G. F. Poe

job was on a core drilling rig in Nebraska. He was made superintendent of production of the Terre Haute division in 1947 and has served as assistant to the manager of production since January 1953.

Henry was initiated into the oil business as a gang pusher at Stoy, Illinois in 1919. He served as district foreman at Kilgore and Rodessa, Texas, Haynesville, Louisiana, and Reed City, Michigan, before his promotion to division production superintendent at Mt. Pleasant and Grand Rapids, Michigan in 1943. He moved to Casper, Wyoming in 1948 and to Houston in 1950, serving in both divisions as production superintendent.

Grimes began as a warehouseman in Byron-Garland field, Wyoming, in 1934. In 1950 he was transferred to Houston as superintendent of the Midland district. He was made assistant division superintendent at Houston in 1953.

Poe joined Ohio as a roustabout in Rock River field, Wyoming. Later he served as foreman in the Salt Creek and Neiber Dome areas in Wyoming. Transferred to the Byron field in 1932, he advanced to district superintendent. In 1940 he was transferred to Casper and served as assistant to the Casper division manager. Formerly superintendent of production for the Casper, Wyoming division, he also served in that same capacity for the company's Houston division. In 1950 he was transferred to the general office and promoted to general superintendent of production for the company.

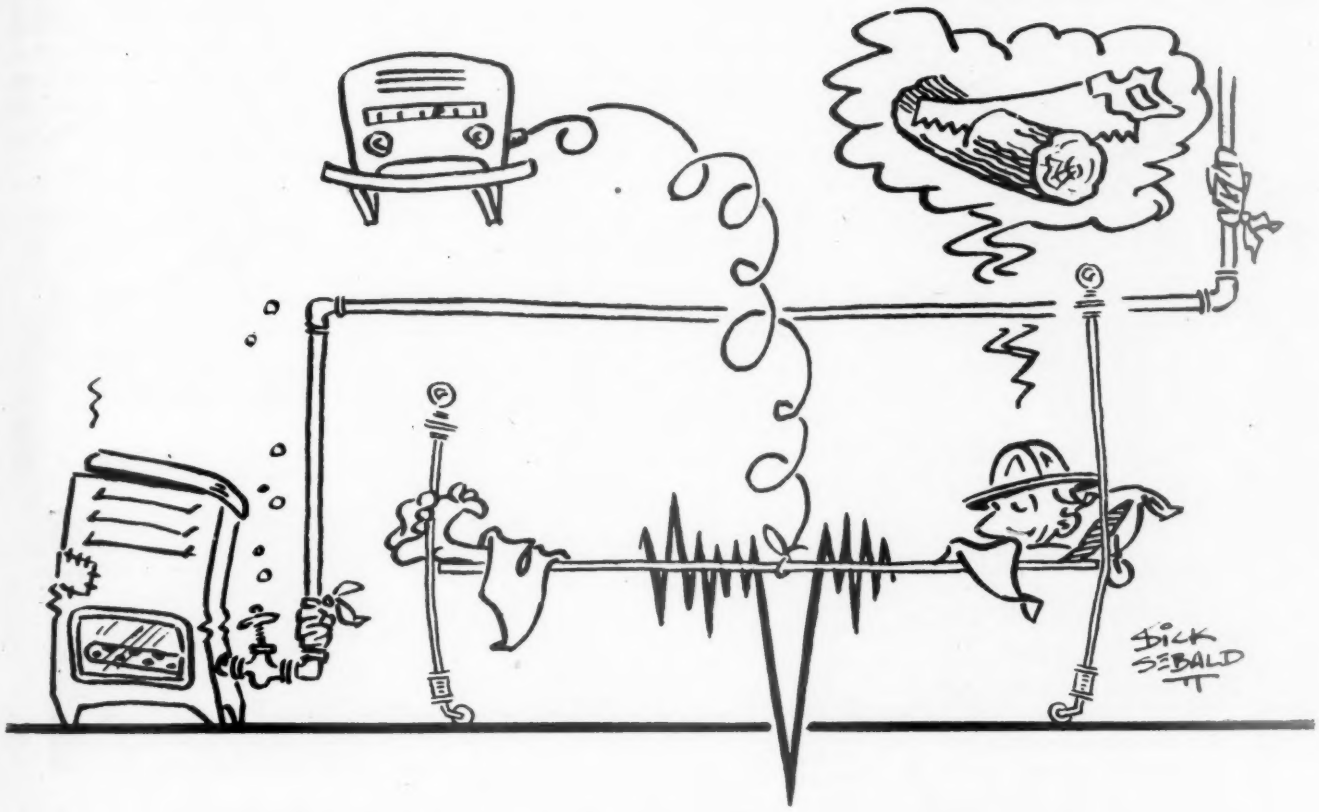
W. Jacque Yost has been appointed Ohio Oil Company's research director. Yost will manage Ohio Oil's projected research laboratory. He was formerly technical advisor to the director of research in Magnolia Petroleum Company's field research department.

O. V. Henry has been promoted to general superintendent of production. Henry was formerly division superintendent of production at Houston, Texas.

J. S. Leonard, manager of Ohio's Sidney, Nebraska production district since 1953, has been promoted to assistant manager of the Casper, Wyoming production division. He succeeds **R. W. McCanne** who advanced to division manager upon the retirement of **H. H. Healy. R. E. McMillen** will replace Leonard.

Leonard joined Ohio Oil as a junior geologist in 1930. He was drilling superintendent at Houston when he moved to Sidney. McMillen, a graduate of the University of Pittsburgh, joined Ohio in 1941. He was transferred in 1943 to Grand Rapids, Michigan, a year later he was made division petroleum engineer for the Houston division before becoming assistant to the general superintendent of production in Findlay in 1952.

Are you missing . . .



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Houston Chapter of Nomads visitors at the September 13 meeting were: Back row: S. R. Chambless, Hughes Tool, Anaco, Venezuela; A. K. Baebel, Hughes Tool, Maracaibo, Venezuela, and W. O. Calvert, Thornhill-Craven Mission Manufacturing, and A-1 Bit and Tool European representative. Front row: O. B. Latrobe, Hughes Tool, New York Chapter Nomads, and R. G. Roberts, Hughes Tool, London, England.

▸ **William H. Meyers, Jr.,** reservoir engineer in the Tulsa, Oklahoma office of Atlantic Refining Company has been named associate reservoir engineer of the company with headquarters in Dallas.

▸ **Paul L. Lyons,** Anchor Petroleum Company, president of the Society of Exploration Geophysicists, has announced the committee chairmen for the 1954-1955 year. Chairmen whose terms will expire at the close of the annual meeting to be held in Denver, Colorado, October 3 to 6, 1955 are: **Roy F. Bennett,** Sohio Petroleum; **Ralph B. Ross,** Canadian Gulf Oil; **Harvey Cash,** The Texas Company; **Rev. J. B. Macelwane,** St. Louis University; **Carl H. Savit,** Western Geophysical; **R. D. Wyckoff,** Gulf Research and Development Co.; **Bart W. Sorge,** United Geophysical; **L. L. Nettleton,** Gravity Meter Exploration Company; **John P. Woods,** The Atlantic Refining Company; **Nelson C. Steenland,** Gravity Meter; **Ben F. Rummerfield,** Century Geophysical; **Robert C. Dunlap, Jr.,** Geophysical Service Inc.; **Sigmund Hammer,** Gulf Research; **John F. Imle,** Geophysical Service Inc.; **Richard A. Geyer,** Humble Oil and Refining Company; **Fred J. Agnich,** Geophysical Service Inc.; **Dave P. Carlton,** Humble, and **W. M. Rust, Jr.,** Humble.

▸ **E. J. Murdoch** has opened offices at 201 First National Bank Building, El Dorado, Arkansas as a consulting geologist. Murdoch was formerly associated with Marine Oil Company as a geologist and manager of exploration. He was also with Atlantic Refining Company before joining Marine.

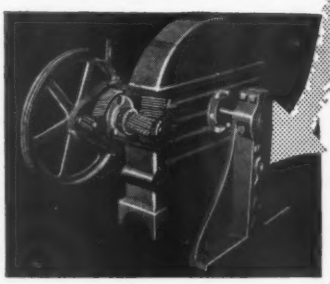
▸ **Morris H. "Benny" Benson,** district geologist in the Tulsa, Oklahoma office of Warren Petroleum Corporation, has been transferred to Midland, Texas as district geologist for the West Texas area.

Kenneth Keene, who has been on the geological staff at Midland, has been promoted to district geologist for the New Mexico area.

R. A. Hobbs, who has been stationed in the Abilene, Texas office, has been transferred to Tulsa to become district geologist for Oklahoma.

▸ **Douglas H. Harnish, Jr.,** has been appointed head of the Department of Petroleum Engineering at Montana School of Mines. Harnish is a graduate of the University of West Virginia. He was a field engineer for the Pure Oil Company and a petroleum research engineer at the University of West Virginia before coming to Montana School of Mines.

THE *Inside* STORY



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The chips that talk...

To the native savage, whose tribe had no conception of a written language, the piece of wood on which the explorer scribbled a message became the wonderful "chip that talks."

The chips of metal that pour in silver drifts from the mighty machines in Sun Ship's Wetherill plant tell their stories, too. Those shown on the 14-foot boring mill tell part of the story of a fast, thorough repair job on ship-propulsion machinery. That job required lifting a 54-ton section of crankshaft from the ship to a 10 ft. x 50 ft. engine lathe, where it was checked for trueness and the journals machined. The crankpins were machined in a huge crankshaft machine. The boring mill operation shown was the facing of the webs of a new section which replaced one of the damaged sections of the crankshaft.

That's the kind of story the versatile men and machines at Sun Ship have been writing for decades . . . in building special machinery of every type for the varied industries that are building a greater America.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) CHESTER, PA.

25 BROADWAY • NEW YORK CITY

"You see Powell Valves everywhere! And with . . .

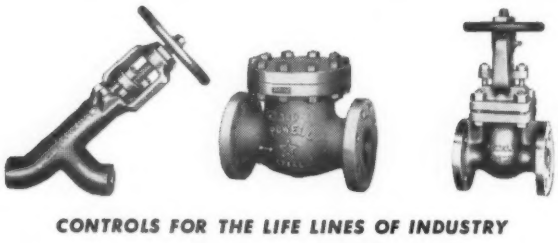
. . . good reason! They're famous for dependability. Economical, too.
What's more, Powell has a complete line."

Famous for dependability

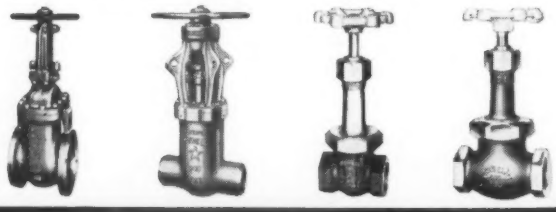
SINCE 1846

Wherever flow requires dependable control, there's *the* place for Powell Valves. Powell probably makes more kinds of valves and has solved more valve problems than any other organization in the world.

Available through distributors in principal cities. Made ⅛" to 30" and for 125 pounds to 2500 pounds W.S.P. Bronze, iron, steel and corrosion-resistant metals and alloys. On problems, write direct to The Wm. Powell Company, Cincinnati 22, Ohio.



CONTROLS FOR THE LIFE LINES OF INDUSTRY



Powell Valves 108th year

Refining . . . Petrochemical . . . Gas Processing

Synthetic Foods?

The Shadow of Things to Come appeared in early October in the voice of one R. E. (Bob) Wilson, board chairman of Standard of Indiana, when he said that within a half-century an appreciable portion of the food of the human race *will* be produced in chemical reactors, from *oil* and *water* and *air*. This is not so far-fetched as we might think; during World War II the German chemists made fats from coal tar and other materials via chemical reactions that are well known. Synthetic "butter" has been made, and even the odor of its intermediates is said to be non-existent. Innumerable reactions are known that may be a part of the synthesis scheme of tomorrow's food factories.

★ ★ ★

From Gas to Uranium

Shell of Canada's new sulfur and gas expansion at Jumping Pound, Alberta, will aid directly in increasing uranium recovery in our northern neighbor's activities. Sulfur-from-hydrogen-sulfide is to be jumped from 30 to 80 tons per day. The extra sulfur will go to Gunnar Mines outfit to be made into sulfuric acid to be used to leach uranium ores to boost Canada's production.

Fluorinated hydrocarbon refrigerants for Canada will be produced locally there instead of being imported from the United States. DuPont's Canadian division, duPont Company of Canada, Ltd., severed recently from the Siamese-twin Canadian Industries, Ltd., is to build, at Maitland, Ontario, alongside new nylon-intermediate-making unit, enough Freon capacity to furnish all Canada's needs, cutting off the USA's outlets there.

★ ★ ★

Exchangers for Turbines?

The British have introduced another innovation in gas-turbine powered motor cars; this is said to reduce fuel consumption materially. British Motor Corporation uses a two-stage compressor driven by a three-compressor turbine, lined up with an entirely separate power-supplying turbine and lastly a cross-flow heat exchanger. Turbine uses waste heat energy in the exhaust gases in the exchanger to save burning of more fuel. Turbine still is far behind piston engine in fuel efficiency.

Plants on the Block

Bids for government-owned synthetic rubber units are much too low as received so far, says the commission charged with their disposal. Government has two choices; put them all in mothballs, or induce industry to offer more. Many outfits have looked at their hole cards, rechecked and reappraised, and have been negotiating on a new basis. The outcome — on the Lap of the Gods.

★ ★ ★

New Catalyst

A brand-new departure in catalyst development comes over the horizon with the new, tested commercially for a year, American Cyanamid high alumina catalyst just put on the market. Made at the company's Fort Worth, Texas, plant, the catalyst contains 25 per cent alumina as compared to the 13 per cent usually put into catalysts for the same service. Its "catalyst activity" is said to be more stable, a 15 to 25 per cent higher "equilibrium activity" is maintained. It is claimed it has improved selectivity of endproduct distribution which is taken to mean that it makes more of the more desirable hydrocarbon components than older type cats make.

One thing the refiner can get his teeth in, stack losses of lines, when using this new catalyst, are definitely lower than are obtained under comparable operating conditions with the old catalyst. Refiners may get samples of the new cat for laboratory studies. Cyanamid is expanding production capacity, will have commercial quantities soon, as manager H. E. Nehms.

★ ★ ★

Here's Boron Gasoline

This new name was thrown at several hundred dealers and distributors several weeks ago by Standard Oil of Ohio, a company that sings its praises in clarion tones as the best ever. Just what boron gasoline is has not been explained at this writing to any satisfactory degree but sounds as though it may be a worthy competitor to the numerous new motor fuels placed on the market in recent months. An advertisement is appearing later in one of the national super-weeklies, extolling the new fuel's virtues and inviting (noncompeting) oil companies to make the same product, inferentially under Sohio's patents or formula.

Brush Control

Six years' experience in controlling brush on rights of way with 2, 4-D and 2, 4, 5-T have demonstrated clearly, reported Pennsylvania Power and Light Company recently, this method of brush control is successful and much less expensive than any other method. Hand cutting an acre is said to be twice as expensive as spraying. Sheardozing and discing would probably be five times as expensive as spraying, the company said at the AIEE in New York in October.

★ ★ ★

Electronic Unit in News

Great and widespread interest has been engendered by the data released recently on the system of electronic controls employed in the 2400 bbl per day Platformer unit placed on stream a short time ago by Rock Island Refining Corporation near Indianapolis. This is the first unit in the world to be controlled entirely by electronic instruments. Extensive data on the system is included in a release that is available from Universal Oil Products Company, 30 Algonquin Road, Des Plaines, Illinois.

★ ★ ★

Royalite Buys Refineries

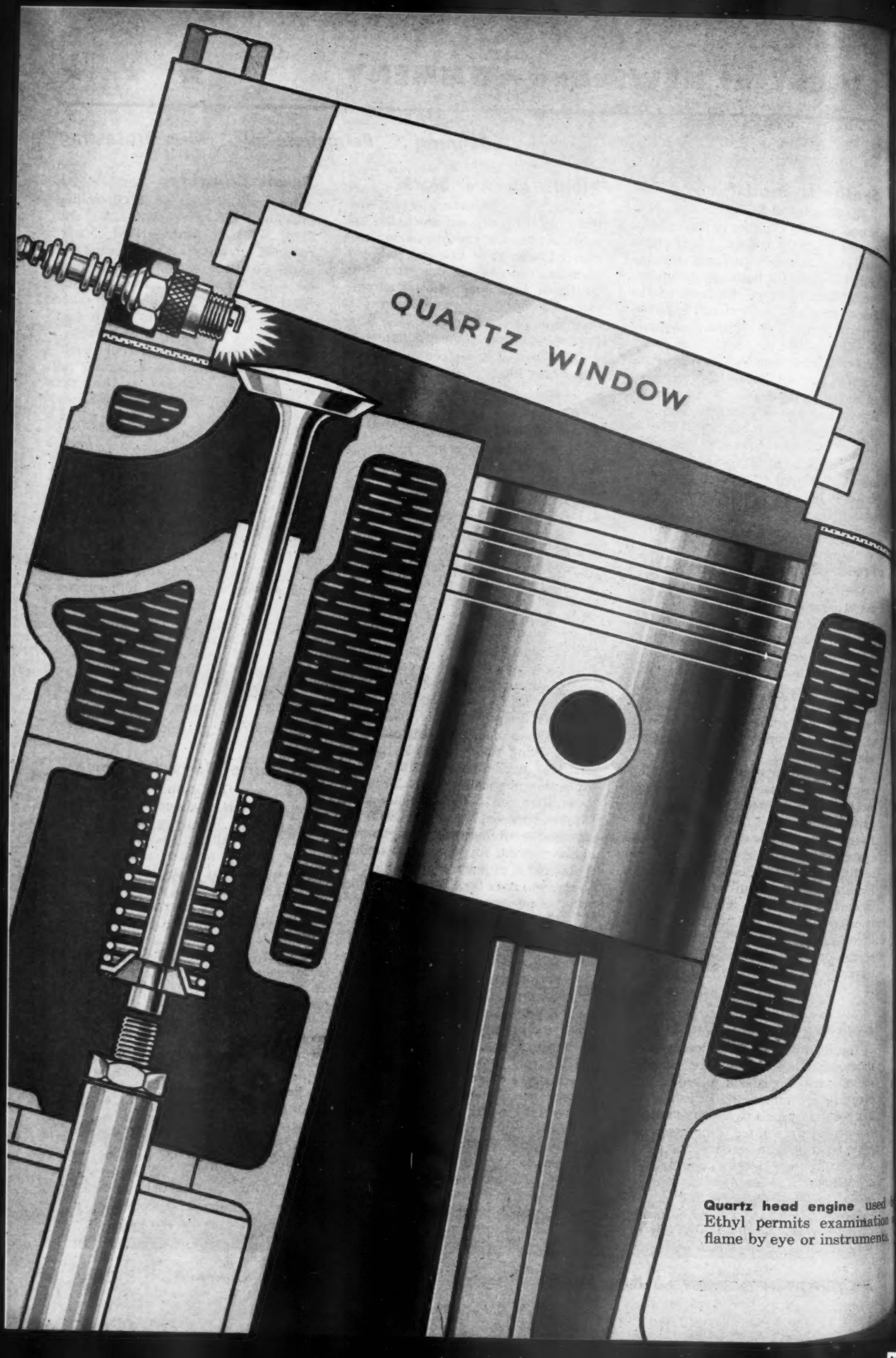
Royalite Oil Company, Ltd., of Calgary, Canada, has purchased the assets of Hi-Way Refineries, Ltd., and its subsidiary, Alberta Hi-Way Refineries, Ltd. Hi-Way operates a 6500-bbl per day refinery at Saskatoon, Saskatchewan, and has more than 130 dealer outlets. Royalite operates refineries at Kamloops, British Columbia, Coleville, Saskatchewan, and Prince Albert. Royalite also has interests in 250 oil wells and 70 gas wells in Canada.

★ ★ ★

Refinery Ups Crude Price

Coincident with the dedication of its new Mandan, North Dakota, refinery, Standard of Indiana raised the price of Dakota crude 50 cents, to $2.50 per barrel, effective October 15. The base is 40 API gravity crude, with 2c per barrel differential for each degree of gravity below that. Plant has a rated capacity of 30,000 bbl per day, and North Dakota is expected to be an exporter (from the state) of petroleum product for the first time in its history.

XUM



Quartz head engine used
Ethyl permits examination
flame by eye or instruments.

"Whirl
engine

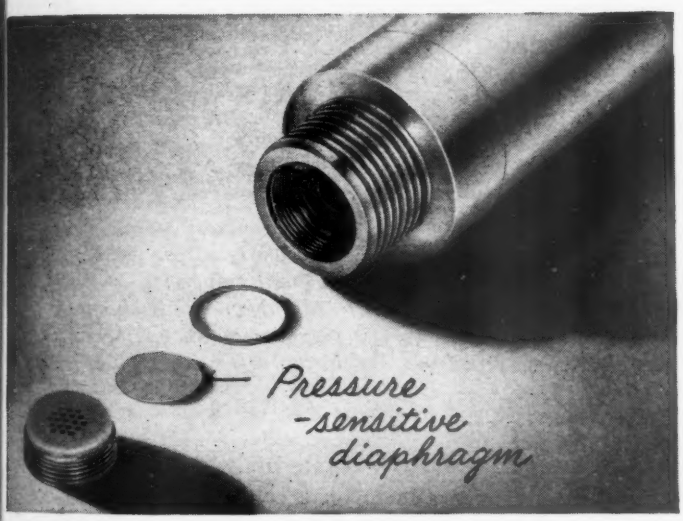
Pressu
senses
and s

XUM

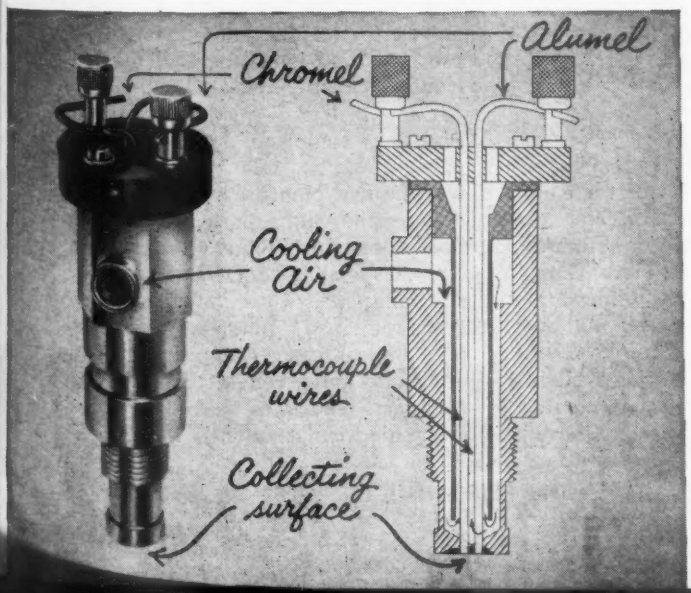
ETHYL RESEARCH TAKES A FLAME APART

to help tomorrow's engines run better

"Whirling pin cushion" designed by Ethyl people samples engine deposits as they are being formed.



Pressure indicator developed by Ethyl research accurately senses the rapidly changing pressures in the engine cylinder and sends the information to an oscilloscope for measurement.



Thermal plug mounted in combustion chamber provides a removable, temperature-controlled surface for collecting samples of combustion deposits.

LOCKED up in the mystery of how gasoline burns is a vital secret. It is known that dozens of chemical combinations are formed and broken down in the flame. But what are they?

It's hard enough to find out what goes on in a candle flame. But when you put the flame in the center of a block of cast iron and permit it to endure less than a thousandth of a second, the problem becomes even more difficult. And the difficulty is further increased since many important changes occur in the fuel as the fuel-air mixture is compressed by the piston before the flame begins.

Yet how much can be done to improve today's engines depends in no small measure on how much can be found out about this vital problem.

Ethyl research people have been working on the problem for many years in many different ways. Recently they have developed new test instrumentation and have used existing instrumentation in new ways, which show great promise in piecing together the answers.

With the help of these new techniques we may all someday know considerably more about how gasoline burns. This will help refiners to make even more effective fuels, which will permit the production of more efficient engines than are practical today.

Ethyl continues its basic research into this vital question.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

XUM

"Kick" for Rocket Fuel

Coating ammonium nitrate with a "hydrophobic material," (along with some carbon black, aluminum, and ferric oxides in a "dispersion" in a liquid binder) and mixing and casting the mass is said to give rocket engines more *oomph* per pound, lower cost for the fuel (less than $1 per lb), and especially the added advantage of smooth burning at low pressures—this last said to bother other fuels considerably—and with a low (?) combustion temperature of *only* 2000 C, or 3632 F! The metallic oxides are said to serve largely as combustion catalysts. Could be a wonderful source of large quantities of rocket fuel in event of war; large capacities for the product now making fertilizer nitrate. Untamed ammonium nitrate can "go off" unexpectedly with disastrous results.

★ ★ ★

Gas "Rocket Primed"

Joining the parade of new gasolines is Sinclair, with Power-X with "increased advantages by addition of the same fuel used to power V-2 rockets, they say, Power-X fuel came out first early in 1953 but has been revised by adding "rocket fuel," and is to be marketed in all the 42 states where Sinclair sells products.

★ ★ ★

Hydrogen Safe Lighting

The first lighting units ever approved by Underwriters' Laboratories for areas where hydrogen is present has been brought out by Safe Lighting, Inc. Standard Oil Development Company has specified these units for use in Hydrofining units, UOP has done the same for their Platformer-licensed units. "Individual, self-contained air pressure" arrangements are employed to prevent ingress of explosive gases or vapors into places where sparks might set off explosions.

★ ★ ★

Asphalt From Shale?

Pursuing its policy of investigating all probable or possible avenues for utilization of shale oil, the U. S. Bureau of Mines experimental laboratories in Colorado and Wyoming has given 500 lb of shale-oil-derived asphalt to the city of Rifle, Colorado to test as street surfacing material. The asphalt was mixed with aggregate in the manner customary in applying other asphaltic materials and the mix has been applied to 10 blocks of city streets. Previously, it is understood, this road material has been applied to roads, etc., around the mine and retort-refinery areas, but is now to be tested where traffic load is heavier and more diversified than it was in earlier tests. Results may indicate the practicability of utilizing very heavy residues from shale oil.

★ ★ ★

Sulfonation for Detergents

A new, continuous sulfonation-sulfation process for making detergents and intermediates therefor is being shown by Girdler Corporation to petroleum, soap, and chemical companies. The process, developed by Girdler's Votator division, employs a "multiport injection Votator reactor."

★ ★ ★

Vapor System Installed

A new $100,000 vapor recovery system at two tank car and truck loading racks in Los Angeles County, California, being built by General Petroleum Corporation will aid in reducing air pollution in that smog-infested area, GP president R. L. Minckler stated recently. This is an effort to comply with the requirement and recommendations of the Backman committee report on air pollution. Since 1946 General Petroleum has spent more than $1,500,000 on control of air pollution.

★ ★ ★

Research "Grants in Aid"

Sixteen grants of money, to aid basic research in chemistry and engineering science, were announced recently by National Science Foundation, part of 176 grants that are the fourth group granted this year. All 16 grants were to western, northern, and eastern colleges and schools, none being made to "oil country" schools or agencies. Five chemistry and 3 engineering problems to be aided have to do with hydrocarbons and/or the petrochemical industry.

★ ★ ★

Benzene Survey

Last month about 60 leading chemical companies received questionnaires seeking capacity, production, and consumption patterns of benzene from the Business and Defense Services Administration. Collated, this information will be used to forecast the national supply and demand picture of this basic aliphatic, and will be available to industry. Within the next 18 months, 125 other chemicals will be surveyed.

To Build Research Center?

Chemical manufacturers may be the first to undertake to build and operate a research center entirely independently, the answer depending on the report of the special committee appointed by Manufacturing Chemists' Association, says MCA prexy William C. Foster. Toxicological research has been emphasized frequently in discussion held over a period of a few years. Report covers problems to study, staff needs, financing required, where to locate, and above all the field and scope of the center's activities.

★ ★ ★

B-T-X From Petroleum

The U. S. Tariff Commission in its final report on synthetic organic chemical production reported that of the 272,700,000 gal of benzene produced in 1953, the petroleum industry supplied 63,000,000 gal (23 per cent)—from no production in 1950. Industry supplied 74 per cent of the toluene and 90 per cent of the xylene.

★ ★ ★

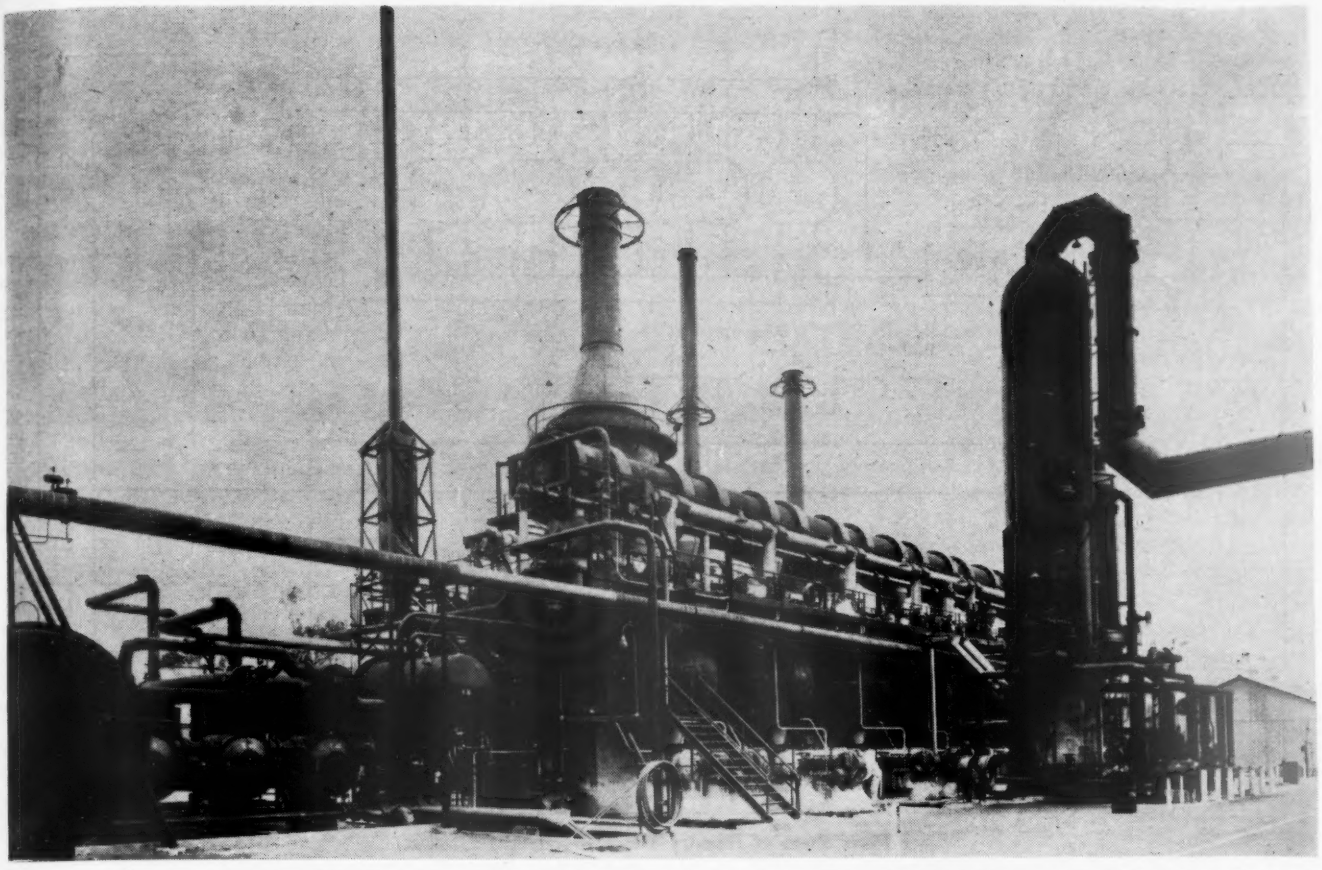
Engineers-Atomic Energy

During the next 10 years some 25,000 engineers will be graduated who must know something of atomic energy, says Dr. R. P. N. Powers, Monsanto Chemical Company atomic project director, speaking before the Congress on Nuclear Engineering at University of Michigan. This number means 10 per cent of all engineering graduates during this next decade.

★ ★ ★

Another Refinery Merger?

Option on a controlling interest in the common stock of Roosevelt Oil and Refining Corporation, Mt. Pleasant, Michigan, has been acquired by Mid-West Refineries, Inc., of Grand Rapids, Michigan. The two plants are said to correlate with each other well in the processes and units operated by each. Roosevelt carried out a $3,000,000 expansion program since the war and Mid-West completed a program of expansion earlier this year. Roosevelt was the first plant in the world to operate a platreating unit; a hydrogenation process for refining aromatics concentrates made from petroleum. The two companies have shown in recent years combined profits that total nearly $750,000. Roosevelt especially is an important gatherer and transporter of Michigan crudes, as well as in its refining-marketing activities.



This view shows the wartime dehydrogenation unit built by Defense Plant Corporation at El Segundo refinery of Standard Oil Company of California. Plant started making butadiene in January, 1944. Since the war it has been producing butadiene-butene mixtures.

DEHYDROGENATION by THE HOUDRY PROCESS

With 10¢ per gal butane, butadiene may be produced at 9.88 cents per pound, exclusive of capital costs, federal taxes

GEORGE F. HORNADAY

GOVERNMENT plans for the disposal of its synthetic rubber plants have aroused increasing interest in the Houdry dehydrogenation process. In addition to providing an attractive method for producing normal butenes and isobutenes, the Houdry process also constitutes the only commercial single step method for the dehydrogenation of normal butane to butadiene.

Many prospective purchasers of the government facilities are investigating the Houdry dehydrogenation process as a method of producing butenes required as feed stocks for most of the government butadiene plants. Considerable interest also has been shown in the use of this process to dehydrogenate isobutane to isobutene which is required for the manufacture of butyl rubber.

The Houdry dehydrogenation process was developed during the early days of World War II for the production of butadiene required for the government's synthetic rubber program. Defense Plant Corporation built two catalytic dehydrogenation plants employing this process at the Toledo refinery of the Sun Oil Company and the El Segundo refinery of the Standard Oil Company of California. The Sun Oil unit designed for the production of 15,000 tons of butadiene per year was dismantled after the war.

The El Segundo plant was originally designed for the production of 15,000 tons of butadiene per year, but has produced as high as 18,000 tons annually. After the war, it was shifted to butadiene-butene production. This plant has been operated almost continuously since it went on-stream in 1944.

EXCLUSIVE

Process Features

1. The Houdry dehydrogenation process is capable of producing low cost butadiene from butane.

2. Saturated light hydrocarbons can be dehydrogenated to mono-and di-olefins in excellent yields by passage of the vapors under controlled conditions of space velocity, temperature, and pressure over catalysts of the chromic oxide-alumina type.

3. High conversion per pass and high product concentration are feasible.

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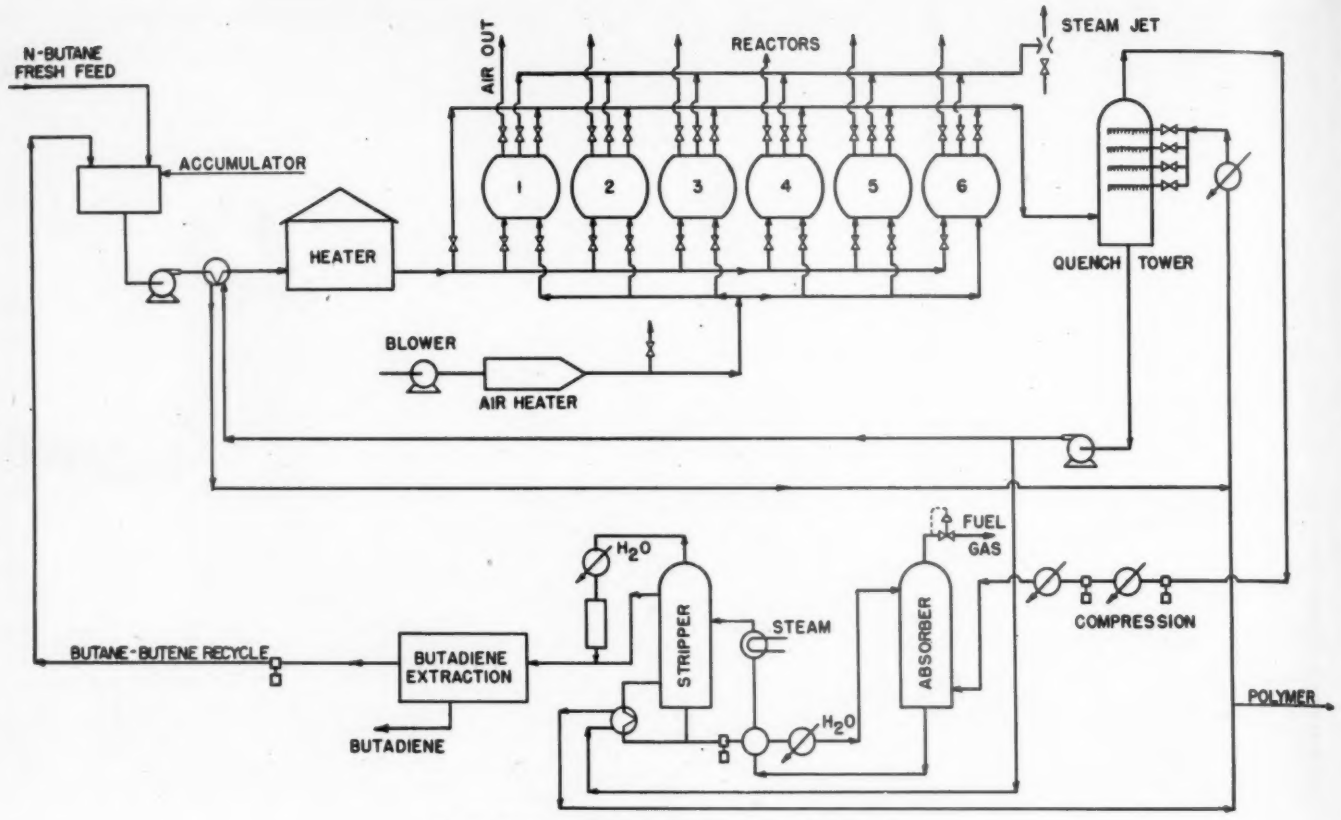


Flow chart of Houdry Dehydrogenation Process.

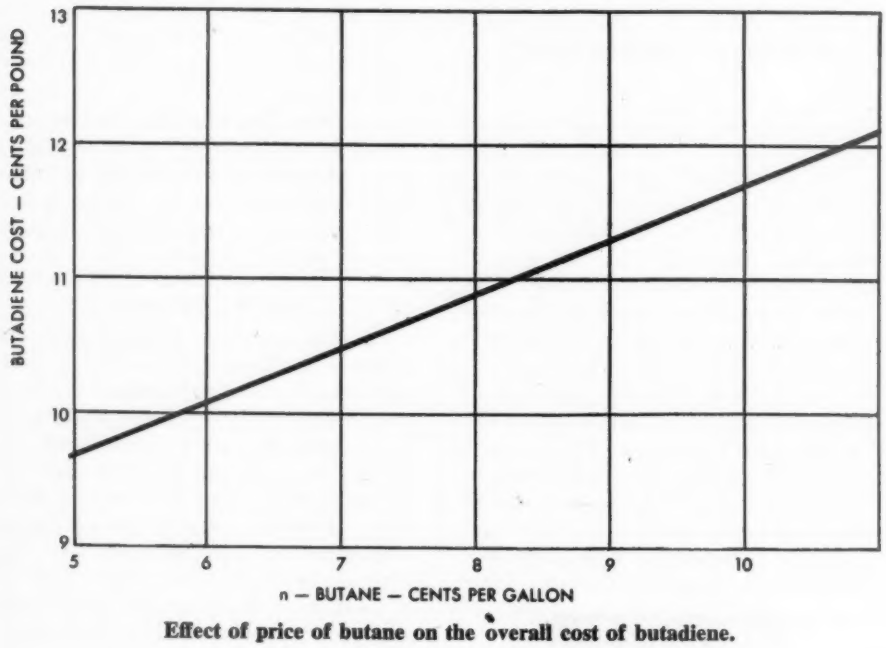
4. Reactants are introduced at substantially reaction temperature, thereby eliminating problems of pre-thermal cracking. Also, temperatures are controlled within the desired range for the reaction.

5. Regeneration is accomplished by the use of fresh air with no limitation of oxygen concentration, and there is no problem of recirculating hot gases. No excessive temperatures are encountered during the regeneration period, thus protecting catalyst life.

6. No expensive special alloy heat-exchange equipment is required in the reactor.

Process Description

The dehydrogenation of butanes and/or butane-butene mixtures is accomplished by passing the fresh feed and the recycle stock from the product-recovery unit over a chromia-alumina type catalyst. The fresh feed and the recycle stock from the recovery plant



Effect of price of butane on the overall cost of butadiene.

The Author

George F. Hornaday is a commercial development engineer for Houdry Process Corporation.

A graduate of Purdue University with a BS degree in chemical engineering. Hornaday joined Houdry in 1940 as assistant manager of the development division. He conducted development work on catalytic processes for making gasoline with fixed-bed units and also engaged in research on moving-bed units.

Shortly after Pearl Harbor, Hornaday was assigned to a special group for the development of new process for the production of butadiene. He directed the operation of the semi-commercial unit and later supervised the loading of commercial catalysts units for Sun Oil Company and Standard of California.

After serving in various administrative posts and supervising research and development on catalytic cracking and catalytic reforming, he was appointed to his present position in 1952.

are pumped from an accumulator through a feed-quench oil exchanger and a heater where the temperature is raised to approximately 1150 F before entering the reactor.

The effluent from the reactor is quenched by direct contact with a circulating quench oil. From the quench tower the effluent passes to a knockout drum prior to the first stage of the 4-stage compressors. The overhead from the last knockout drum passes to a conventional absorber and stripper for recovery of the C_4 and heavier material. The bottoms from this drum pass to the reflux accumulator of the stripper. The effluent from the stripper passes to the recovery and purification unit. Details of the compressor section are not shown in the simplified flow diagram.

The on-stream period of each reactor is followed by a vacuum purge to remove hydrocarbons and then regeneration is carried out with air which is preheated by direct combustion of fuel in the air stream. At the end of the regeneration period the reactor is evacuated by means of a stream ejector prior to the following on-stream period. Thus, in a three-reactor group, one reactor receives hydrocarbon feed while the second receives regeneration air and the third undergoes valve changes and purging operations.

The major process conditions are as follows:

Butadiene production.

Average temperature	1125 F
Pressure	5 in. Hg Abs
Space rate	1–1.5 vol. feed/vol. cat./hr
On-stream period	8–10 min

Mono-olefin production.

Average temperature	1125 F.
Pressure	10 psig
Space rate	1.5–2.0 vol. feed/vol. cat./hr.
On-stream period	8–10 min.

It will be noted that dehydrogenation to mono-olefins, in contrast to butadiene production, is conducted at atmospheric or slightly higher pressures, (if butadiene production is to be minimized) and the space rate adjusted to balance coke formation with the necessary heat of reaction. Line sizes and compressor requirements are, of course, smaller for the mono-olefin operation due to the higher operating pressure. Approximately 1-2 per cent of butadiene is produced at the higher operating pressure.

If it is desired to produce additional butadiene as well as butenes, the process is operated under reduced pressure and the desired quantity of butenes is separated from the recycle stream before the remaining butane-butene is recycled. This procedure decreases the yield of butadiene as compared to the operation for butadiene alone, because of lower butene content in the feed to the reactor.

Typical yield data for the production of butadiene, butene, and butadiene-butene are shown in Tables 1, 2, and 3.

Process Factors

Catalyst. The dehydrogenation catalyst, utilized in the form of cylindrical pellets, consists of active alumina impregnated with 18-20 per cent chromic oxide. The catalyst bed depth is determined largely by the pressure drop during the onstream period. It is desirable to have as low a pressure drop as possible during the on-stream period when operating at a low absolute pressure.

Commercial operation has proved the ruggedness of the catalyst. Although catalyst life depends on the temperatures and length of cycle employed, plant experience indicates a normal life of about six months.

Studies have been conducted to determine the effects of various impurities including water, carbon dioxide, and ammonia that might enter the reactor. Water causes a temporary decrease in catalyst activity. Carbon dioxide and ammonia in small quantities have no particular undesirable effects on catalyst activity.

Experience has shown the necessity of preventing contamination of the catalyst with iron. Small amounts of iron oxide become catalytically active at process conditions, with resultant formation of large amounts of coke and light gas. In addition, spalling and breakage of the catalyst occur.

Temperature-Pressure. Dehydrogenation equilibria indicated that high temperatures (1100-1150 F) and low partial pressures are required for the production of di-olefins. Pressure studies made between 5 and 30 in. of mercury absolute showed that all reactions varied approximately linearly with pressure. The yields of butene, cracked products, and coke increased with increasing pressure, whereas the yield of butadiene decreased.

From a process standpoint, lower pressures are desirable as they give greater selectivity to the dehydrogenation reactions, higher butadiene yields, and more favorable process net heats. Operating at pressures as low as two and one-half pounds psia has been found desirable for the production of di-olefins.

Space Rate. Space rate can be varied considerable without markedly affecting the yield of products. The side reactions, particularly coke formation, are reduced substantially by increased space rates. Adjusting the space rate is the most effective way to balance the heat of reaction with the heat of carbon combustion.

Feedstock. Plant experience shows that 11 to 11.5 per cent butadiene per pass can be produced starting with normal butane and recycling the butane-butene mixture from the purification step. Yield per pass can be increased by increasing the butene content of the fresh feed.

The effect of butadiene in the recycle stock has been studied to evaluate the importance of butadiene extraction efficiency. Results indicate that an increase in butadiene content of the recycle feed increases the production of coke and cracked products and decreases the net production of butadiene. Commercial plant operation has shown that over 50 per cent of the butadiene in the recycle is destroyed.

TABLE 1. Production of Butadiene.

	Fresh feed Percent Wt	Recycle Percent Wt	Total feed Percent Wt	Reactor product Percent Wt	Ultimate yield Percent Wt. butane fresh feed
Hydrogen				1.9	10.1
Methane				1.0	5.3
C_2				1.1	5.9
C_3				1.1	5.9
Isobutane	0.5	(1)	(1)	(1)	...
Isobutene	...	(1)	(1)	(1)	...
n-Butene	...	41.4	33.6	33.6	...
n-Butane	99.5	57.9	65.8	47.0	...
Butadiene	...	0.7	0.6	11.1	55.8
C_{5+}	...	...	...	0.5	2.7
Coke	...	...	...	2.7	14.3
Total	100.0	100.0	100.0	100.0	100.0

(1) Included in n-C_4 fractions.

TABLE 2. Production of Butene.

Material	Charge Percent Wt	Product Percent Wt	Ultimate yield at high conversion Wt Percent n-Butane fresh feed
Hydrogen		1.6	3.4
Methane		2.4	5.1
C_2		2.7	5.8
C_3		3.4	7.2
Isobutane	0.5	0.3	Tr
Isobutene		0.2	Tr
n-Butene		32.0	68.2
n-Butane	99.5	52.6	....
Butadiene		2.0	4.3
C_{5+}		0.6	1.3
Coke		2.2	4.7
Total	100.0	100.0	100.0

Note: Ultimate yield of butene would be increased at lower conversion and at lower pressure.

TABLE 3. Production of Butene and Butadiene.

	Fresh feed percent wt	Recycle percent wt	Total feed percent wt	Reactor product percent wt	Ultimate yield percent wt butane fresh feed
Hydrogen				2.1	7.4
Methane				1.4	4.9
C_2				1.5	5.3
C_3				1.6	5.6
i-Butane	0.5	(1)	(1)	(1)	
i-Butene		(1)	(1)	(1)	
n-Butenes		35.6	25.5	34.9	33.1
Butadiene		0.7	0.5	9.8	32.7
n-Butane	99.5	63.7	74.0	45.6	
C_{5+}				0.5	1.8
Coke				2.6	9.2
Total	100.0	100.0	100.0	100.0	100.0

(1) Included in n-C_4 fraction.

Studies of thermal polymerization and cracking of both feed and product have been made. A typical recycle feed at 1125 F, one atmosphere pressure and 10 sec contact time lost 12.5 per cent to cracked products and 2.5 per cent to polymers. The rates of these reactions vary linearly with contact time. With higher butadiene content, the rate of polymer formation is considerable greater, whereas the production of cracked products remains about the same. These results indicate the necessity of providing feed preheating and reaction product quenching equipment which give a minimum contact time at elevated temperatures to minimize stock losses to cracked products and polymers.

Construction Materials. Reactors for Houdry dehydrogenation process are characterized by simplicity of design and construction. Each reactor is a steel shell lined with ceramic tile. The use of steels in reactor construction is held to a minimum, because the alternating oxidizing and reducing conditions at elevated temperatures produce an active oxide surface on these materials which in turn promotes cracking and coking.

The absense of tubes (except thermocouple tubes) facilitates charging and discharging of catalyst. Contributing to low cost of reactor construction is the fact that expensive special alloy is minimized.

Cost of Producing Butadiene

To illustrate the economics of producing butadiene from normal butane, a study is presented for a case involving the production of 26,500 tons per year of butadiene. For this case the Houdry dehydrogenation process is used, and the cuprous ammonium acetate process, which is one of the available processes, is assumed for extraction and purification of the butadiene.

On the basis of this study, the cost of butadiene is 9.88 cents per pound if the cost of normal butane is 10 cents per gallon. The costs include direct operating expenses, amortization, insurance and local taxes, maintenance, and general plant overhead. Operating capital and federal taxes are omitted. The detailed summary of the costs when the butane is available at 5.5 cents per gallon is shown in Table 4. The effect of the butane price on the final cost of producing butadiene is shown in Fig 1. An increase in butane price of 1 cent per gallon increases the cost of butadiene approximately 0.39 cents per pound.

The utility requirements of the Houdry dehydrogenation section and the cuprous ammonium acetate butadiene purification section are tabulated in Table 5.

TABLE 4. Economics of Houdry butane dehydrogenation.

			$/C.D.	¢/lb butadiene
Fixed charges				
(Investment $9,000,000)				
Amortization	10 percent x $9,000,000		2,466	1.70
Insurance & Taxes	3 percent x $9,000,000		740	.51
Maintenance	6 percent x $9,000,000		1,479	1.02
General Plant Ovhd	½ maintenance + 100 percent labor & supervision		1,235	.85
Total			5,920	4.08
	Amount	Rate		
Direct operating labor				
Labor	7⅓ men per shift	$2.25/hr	396	.27
Supervision	25 percent of labor		99	.07
Overhead	20 percent of labor & supervision		99	.07
Total			594	.41
Utilities, C.D.				
Power	203,580/kwh	$ .01/kwh	2,036	1.40
Cooling water	19,168M gal/CD	$ .02M gal	383	.26
Steam required				
125 psig	100M lb/CD	$ .25/M lb	25	.02
15 psig	585M lb/CD	$ .25/M lb	146	.10
Steam produced	1482M lb/CD	$ .25/M lb	370 credit	.25 credit
Net fuel required	2297M BTU/CD	$ .15/M BTU	345	.24
Boiler feed water	199M gal/CD	$ .10/M gal	20	.01
Quench oil	760 gal/CD	$ .10/gal	76	.05
			2,661	1.83
N-Butane fresh feed	56,923 gal/CD	$ .055/gal	3,131	2.16
Chemicals			280	.19
Catalyst				
Active	1800 lb/CD	$ .45/lb	810	.56
Inert	448 lb/CD	$ .093/lb	42	.03
			852	.59
Royalty				
Houdry	145,200 lb/CD	3/8¢/lb butadiene	542	.37
Butadiene purification	145,200 lb/CD	1/4¢/lb butadiene	363	.25
			908	.62
Total			$14,346	9.88

TABLE 5. Houdry butane dehydrogenation process.
Utility Requirements.
Production 26,500 ton/year.
Butadiene on-stream 87 per cent.

	Dehydrogenation	Purification	Total
Cooling water, gpm	6,000	9,300	15,300
Power, kw	7,150	2,600	9,750
Steam, lb/hr			
125 psig required			
Maximum	19,500		19,500
Average	4,800		4,800
125 psig produced	71,000		71,000
15 psig required		28,000	28,000
Fuel, M BTU/hr			
Required	235		235
Produced	125		125
Net required	110		110
Boiler feed water	56,000		56,000
Chemicals, lb/SD			
Copper shot		250	250
Ammonia		1,500	1,500
Acetic acid		290	290
Inhibitor		67	67
Catalyst, lb/SD			
Active	1,800		1,800
Inert	2,240		2,240

Air blower, compressors (including refrigeration) and all pumps, except knockout drum liquid discharge pumps, are motor driven.

TABLE 6. Effect of fuel and steam costs on butadiene cost.
Butane 5.5¢ gal

Fuel, ¢/M BTU	15	20	25	30	40
Steam, ¢/M lb	25	33	42	50	67
Butadiene cost ¢/lb	9.880	9.914	9.944	9.979	10.044

If the price of fuel gas is increased and the price of steam is adjusted for the increased fuel price, the effect on the cost of butadiene is very slight, because steam is produced by the process. The effect of fuel prices is shown in Table 6.

For the purposes of these studies, the investment was estimated at $9,000,000. Amortization charges were 10 per cent, insurances and taxes 3 per cent and maintenance 6 per cent per year based on the investment. * * *

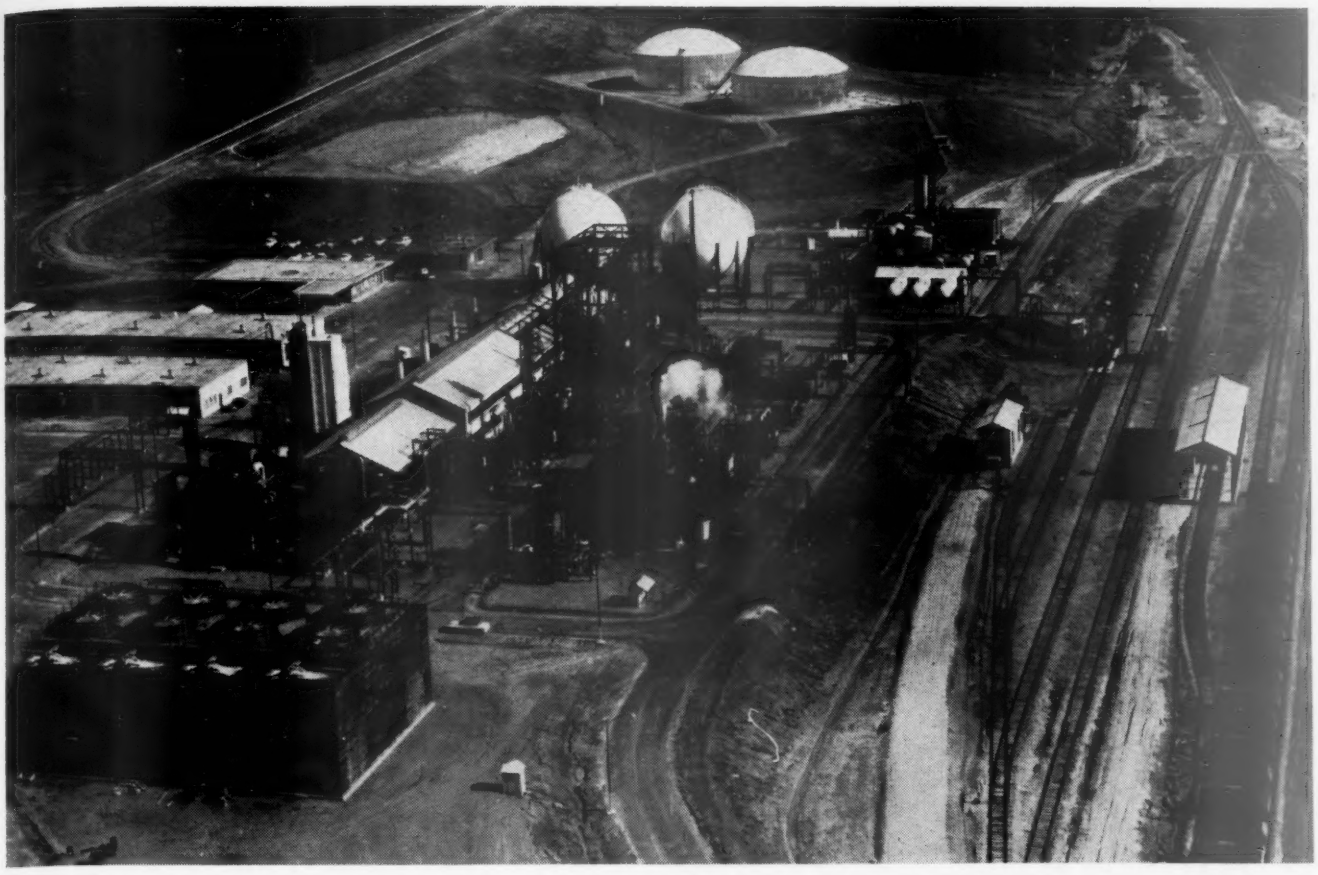
PLANT AID

Flow Line Heater Fuel "Jeep"†

Z. C. BENNETT*

The purpose of this device to provide 6-lb fuel for indirect flow line heater from high pressure (2000-5000 lb) distillate flow line. A 1-in. fuel preheater coil is usually standard equipment in the heater. An additional coil of ¼-in. pipe or tubing is installed in the field. From the warm flow line leaving the heater a 2-in. line is run underground, sloping upward, to the opposite end of the heater. Here, the line rises straight up approximately 2-ft. The lower end of the 30-in. nipple has a perforated baffle welded inside. A sufficient amount of ordinary 30-in. galvanized 16-mesh screen is rolled into a tight bundle and forced into the nipple. The nipple is topped off with a ¼-in. choke welded in, a 2-in. by ¼-in. swage nipple, and a ¼-in. swage nipple, and a ¼-in, plug valve. From here connection is made to the ¼-in. coil previously installed in the heater. Coming out of the ¼-in. coil the heated high pressure gas is first reduced through a ¼-in. Mecca regulator, then piped to the original 1-in. coil. Any 1-in. regulator suitable for 500 lb wp is connected to the outlet of the 1-in. coil and used for final pressure reduction of fuel to the thermostatically controlled burner valve. A relief valve for safety is installed between the two regulators. The choke above the screen is primarily for safety in case of failure of the ¼-in. piping.

*Continental Oil Company, Basile, Louisiana.
†Class C, honorable mention, NGAA Kinks Contest.



Spencer Chemical ammonia plant at Vicksburg, Mississippi, is now producing anhydrous ammonia and other nitrogen products.

Petrochemicals Developing More Capacity

All predictions regarding growth of the petrochemical industry have proved to be too conservative

ARCH L. FOSTER*

ANY roster of petrochemical plant construction data is in the same category as any book of applied chemistry, engineering, etc., in petroleum or petrochemical technology — it is obsolescent before it is off the press. The rapid pace maintained by the petrochemical industry is such that between the gathering of data and its publication, so many new developments have begun or have changed pace, that the summary is incomplete. It is in this mind that the accompanying partial assembly of data on petrochemical facilities is presented.

This installment concludes The Petroleum Engineer's effort to add partially at least to the sum total of data available in the literature on petrochemicals. Significant indeed is the statement by B. T. Brooks (March, 1954, page C-9 et seq) in effect that every prophet who forecasts on the developments of products demands for petroleum in the past has been much too conservative, and that following history showed results in excess of the most sanguine predictions.

Unfortunately data in this extended survey are far from complete. This shortage of facts is traceable largely to the wide differences in company policy regarding release of company information. Some companies filled out questionnaires nearly completely, and went to considerable pains to make the data complete. Others gave only the most essential data, still others merely admitted that they are operating, or building a chemical plant at a given spot. A few refused to divulge any data whatever.

Other articles and tabulations of data were presented during 1953 as follows:

Refining & Petrochemical Edition:
April, 1953, page C-68 et seq.
July, 1953, page C-5 et seq.
October, 1953, page A-42.

It is planned to revise and bring up to date, periodically, essential facts regarding progress and developments in the petrochemical field, in these pages.

(See next page.)

EXCLUSIVE

*Editor Refining, Petrochemicals.

Survey of petrochemical operations (1954)

Plant	Location	Status	Number of Employees: Approx. Plant Investment	Technical & Admin.	Clerical & Non-Tech.	Approximate Raw Material Capacity	Products Manufactured or Producible: Product	Amount Capacity
Allied Chem.—Nitrogen Division	Hopewell, Virginia	Operating	—	—	—	Natural gas	Ammonia, urea, etc.	
Allied Chem.—Nitrogen Division	Omaha, Nebraska	Operating	—	—	—	Natural gas	Ammonia, urea, etc.	
Alox Corporation	Niagara Falls, N. Y.	Operating	$500 m	6	40	10 mm lb/yr	Rust preventives	10 mm lb/yr
		(300 kva — 200 bhp — 1200 compressor hp at 200 psig)					Petroleum oxidates	
Atlantic Refining	Philadelphia, Pa.	Operating	—	—	—	Hydro. gases & liquids	Detergents, ammonia	
Atlantic Refining	Petreco, Texas	Operating	—	—	—	Hydro. gases & liquids	Detergents, ammonia	
Brea Chemicals	Brea, Calif.	Building	$13.7 mm (leased)	14	11	Ammonia—85,775 T/yr Car. diox.—25,550 T/yr		
Canadian Industries	Maitland Ontario	Operating	—		Total 672		Adipic acid, hexamethylene, diamine	
		(15,000 kw — 7500 bhp — 2000 compressor hp at 125 psig)						
Carbide and Carbon Chemicals	Institute, W. Virginia	Operating	—	—	—	Natural gas	Oxidized hydrocarbons	
Carbide and Carbon Chemicals	Marietta, Ohio	Operating	—	—	—	Natural gas	Styrene	
Carbide and Carbon Chemicals	S. Charleston, W. Va.	Operating	—	—	—	Natural and refinery gas	Oxidized hydrocarbons	
Carbide and Carbon Chemicals	Texas City, Texas	Operating	—	355	2273	Alcohols, aldehyds, amines, esters, glycols, etc.		
Carbide and Carbon Chemicals	Whiting, Indiana	Operating	—	—	—	Glycols, alcohols, organic acids		
Carlisle Chemical Works	Reading, Ohio	Operating	—	—	—	Petroleum fractions	Cutting oils, additives	
Chemstrand Corp.	Decatur, Fla.	Building	—	—	—	Natural gas	Acrylonitrile, etc.	
Columbia-Southern Chem. Corp.	Barberton, Ohio	Operating	—	—	—	Ethylene	Perchlorathylene	
Columbia-Southern Chem. Corp.	Natrium, W. Virginia	Operating	—	—	—	Petroleum fractions	Chlorinated benzene	
Consolidated M & S	Calgary, Alberta, Canada	Operating	—	14	300	Natural gas 10 mm ft³	Ammonia—260 T/day	
		(18,000 kw — 500 bhp — 15,350 compressor hp total)					Am. nitrate—200 T/day	
Deep Rock Oil	Cushing, Oklahoma	Operating	—	—	—	Petroleum fractions	Aromatics	
Diamond Alkali		Building	—	—	—	Refinery gases	Perchlorethylene	
Dow Chemical	Gardena, California	Operating	—	—	—	Ethylene, benzene	Ethylbenzene, styrene	
Dow Chemical	Pittsburg, California	Operating	—	—	—	Natural gas	Alkyl chlorides, carbon tet., etc.	
Dow Chemical	Torrance, California	Operating	—	—	—	Ethylene, benzene	Styrene	
Dow Chemical	Midland, Michigan	Operating	—	—	—	Ethylene, propylene	Stryene, chloro. products	
Dow Chemical	Freeport, Texas	Operating	—	—	—	Ethylene, propylene, benzene	Styrene, chloro. products	
E. I. du Pont de Nemours	La Porte, Texas	Operating	—	—	—	Benzene	Benzene-hexachloride (BHC)	
E. I. du Pont de Nemours	Belle, W. Virginia	Operating	—	—	—	Benzene, cyclohexane	Adipic acid, hexamethylene diamine	
Esso Standard Oil	Linden, New Jersey	Operating	—	—	—	Refinery gases	Alcohols, dienes, ethers, aromatics	
Ethyl Daco Corp.	Freeport, Texas	Operating	—	—	—	Ethylene	Ethylene dibromides	
Foster-Grant	Baton Rouge, La.	Design	$5 mm (reported)	—	—	Ethylene, benzene	Styrene	
General Petroleum Corp.	Torrance, California	Operating	By product plt.	—	—	Refinery gases	Ammonium sulfate	
Goodrich-Gulf Chemicals	Orange, Texas	Planning	—	No data released				
Griffin Chemical	Richmond, California	Planning	—	—	—	Crude sulfonates, naphthenates	Naphthenic acids, oil additives	
Gulf Oil Corp.	Port Arthur, Texas	Operating	—	—	—	Ethylene, iso octyl alcohol, doubling ethylene capacity		
Hercules Powder	Gibbstown, New Jersey	Building	—	—	—	Cumene	Phenol, acetone, p-crisol, alcohols	
Hooker Electrochemical	Niagara Falls, N. Y.	Operating	—	—	—	Aromatics, wax, pyridine, phenol, etc.	Chlorinated hydrocarbons	
Koppers	Port Arthur, Texas	Planning	—	—	—	Ethylene	Ethylebenzene, poly.	
Koppers	Monaca, Pennsylvania	Operating	—	—	—	Ethylene	Styrene, polystyrene	
Lubrizol Corp.	Cleveland, Ohio	Operating	—	—	—	Lube oil additives		
Lubrizol Corp.	Houston, Texas	Operating	—	—	—	Lube oil additives		
Lubrizol Corp.	Niagara Falls, Ontario, Can.	Operating	—	—	—	Lube oil additives		
Monsanto Chemica	Avon, California	Building	—	—	—	Hydrocarbon by products	Phenol.	
The Neuille Co.	Pittsburgh, Pennsylvania	Operating	—	—	—	Resins, solvents, special chem.		
The Neuille Co.	Anaheim, California	Operating	—	—	—	Resins, solvents		
Oronite Chemica	Oak Point, Louisiana	Operating	—	—	—	Lube oil additives		
Pan American Ref.	Texas City, Texas	Operating	—	26	130	Naphtha gasoline 22 mm gal/yr	Aromatics, polymers, placticizers, resins	6 mm gal/yr
		(700 kw — 800 bhp)						
Pennsylvania, Indiana Chem.	Chester, Pennsylvania	Under design	$2.5 mm	40	210	1000 BID—	Aromatics, resins (styrene, idene) "60% of charge"	
		(1000 kw — 1500 bhp — 250 compressor hp at 200 psig)				1500 BID		
		1000 compressor hp at 600 psig)						
Purex Corp.	St. Louis, Missouri	Operating	—	—	—	Hydrocarbons	Sulfonated,alkyl, arom.	
Purex Corp.	South Gate, California	Operating	—	—	—	Hydrocarbons		
Republic Oil Ref.	Texas City, Texas	Operating	—	—	—	Light olefins, paraffins	Tetramer	—120 BID
							Butane-butylene	—2000 BID
							Propane	—700 BID
Richfield Oil	Watson, California	Building	—	—	—	Refinery gases	Ethylene	
Salt Lake Chemical (Originally Mill Creek Chem.)	Salt Lake City, Utah	Building	$7.8 mm	16	64	Natural gas	Anhydrous ammonia	120 T/day
		(7600 kw — 10,700 compressor hp)					Dry ice	30 T/day
Sharples Chemicals	Wyandotte, Michigan	Operating	$5.5 mm	60	385	Pentane-tri-i-butylene 110 mm lb/yr	Amylalcohols, acetate, phenols, chloride, etc.	70 mm lb/yr
		(400 kw — 202 bhp — 1000 engine hp — 110 m ft³/hr at 100 psig)						
Shell Oil—Canada	Montreal East, Que.	Operating	$4 mm	6	40	Propane-propylene 120 m lb/d	I-propylalcohol	10 mm lb/yr
		(620 kw — 910 bhp — 24 m ft³/hr at 65 psig)					Acetone	10 mm lb/yr
Sinclair Refining	Houston, Texas	Operating	—	—	—	Butylenes, pet. fractions	Butadiene, sulfonates	78 m T/yr
Sinclair Refining	East Chicago, Indiana	Operating	—	—	—	—	Lube oil additives	
Sinclair Refining	Marcus Hook, Pa.	Operating	—	—	—	Propylene, heavy fractions	Tetramer, cresylic acids	
Sinclair Refining	Sand Springs, Oklahoma	Operating	—	—	—	—	Demulsifying agents	
L. Sonneborn Sons	Petrolia, Pennsylvania	Operating	—	—	—	Petroleum fractions	Sulfonates	
Standard Oil (California)	Richmond, California	Operating	—	—	—	Cumene	Phenol	35 mm lb/yr
							Acetone	21 mm lb/yr
Standard Oil (California)	Richmond, California	Operating	—	—	—	Benzene, propylene tetramer	Detergent alkane	
Standard Oil (California)	Richmond, California	Operating	—	—	—	Ortho-xylene	Phthalic, anhydride	
Standard Oil (California)	Richmond, California	Operating	—	—	—	Butane, butylenes	Polybutene	
Standard Oil (California)	Richmond, California	Operating	—	—	—	Xylenes	Para-xylene	
Standard Oil (California)	El Segundo, California	Operating	—	—	—	Xylenes	Para-xylene	
Sun Oil	Marcus Hook, Pa.	Operating	$15 mm	—	—	—	Aromatics	3650 b/d
							Hydrogens	13.5 mm ft³/d
Sun Oil	Marcus Hook, Pa.	Building	—	—	—	—	Para-xylene	
Union Oil	Wilmington, California	Operating	$200 m	—	—	—	Methyl & ethyl mercaptan	500 m lb/yr
Union Oil	Wilmington, California	Operating	$600 m	—	—	Refinery gases	Sulfur	17 m st/yr
Union Oil	Wilmington, California	Operating	$1 mm	—	—	—	Ammonia sulfate	18 m st/yr
Union Oil	Santa Monica, California	Operating	$825 m	—	—	—	Dry ice	18 m st/yr
Utah Chemical	Salt Lake City, Utah	Development	$18.8 mm	—	—	Nitrogen ca' 75 m T/yr	Ammonia, am. nitrate	
Visco Products Co.	Sugarland, Texas	Operating	—	12	25	150 m gal	Oil treating chemicals	—
Voseo Chemical Products	Montreal, Canada	Operating	—	—	—	Lanryl alcohol, etc.	Sulfonates	
Wyandotte Chemicals Corp.	Wyandotte, Michigan	Operating	—	—	—	Petroleum fractions	Glycols, sulfonates, detergents	

Aerial view of Kendall Refining plant, Bradford, one of the oldest and best known of the Pennsylvania lubricating oil refiners.

Identification of Pennsylvania Lubricating Oils By Refractivity Intercept

Oils of Pennsylvania origin are differentiated definitely from other oils by this easily determined property

RICHARD PUTSCHER and MARK FRED

PROPER enforcement of regulations requiring that a product be representative of the claims made for it is only as effective as the analytical method, or methods, used in the vigilance program.

Identification of Pennsylvania lubricating oils has been accomplished through the years with various methods, such as specific gravity, viscosity index, and optical rotation. Since late in 1947 Armour Research Foundation has used an infrared absorption[1] method to identify Pennsylvania oils.

Research has been conducted also on analyzing for Pennsylvania oil by the physical properties of refractivity intercept[2,4] and density. Background of this method will be discussed in this paper. The properties of refractivity intercept (n_D-θ.5d) and density have been used extensively for the analysis of compounds and classes of compounds in the gasoline fraction of petroleum.

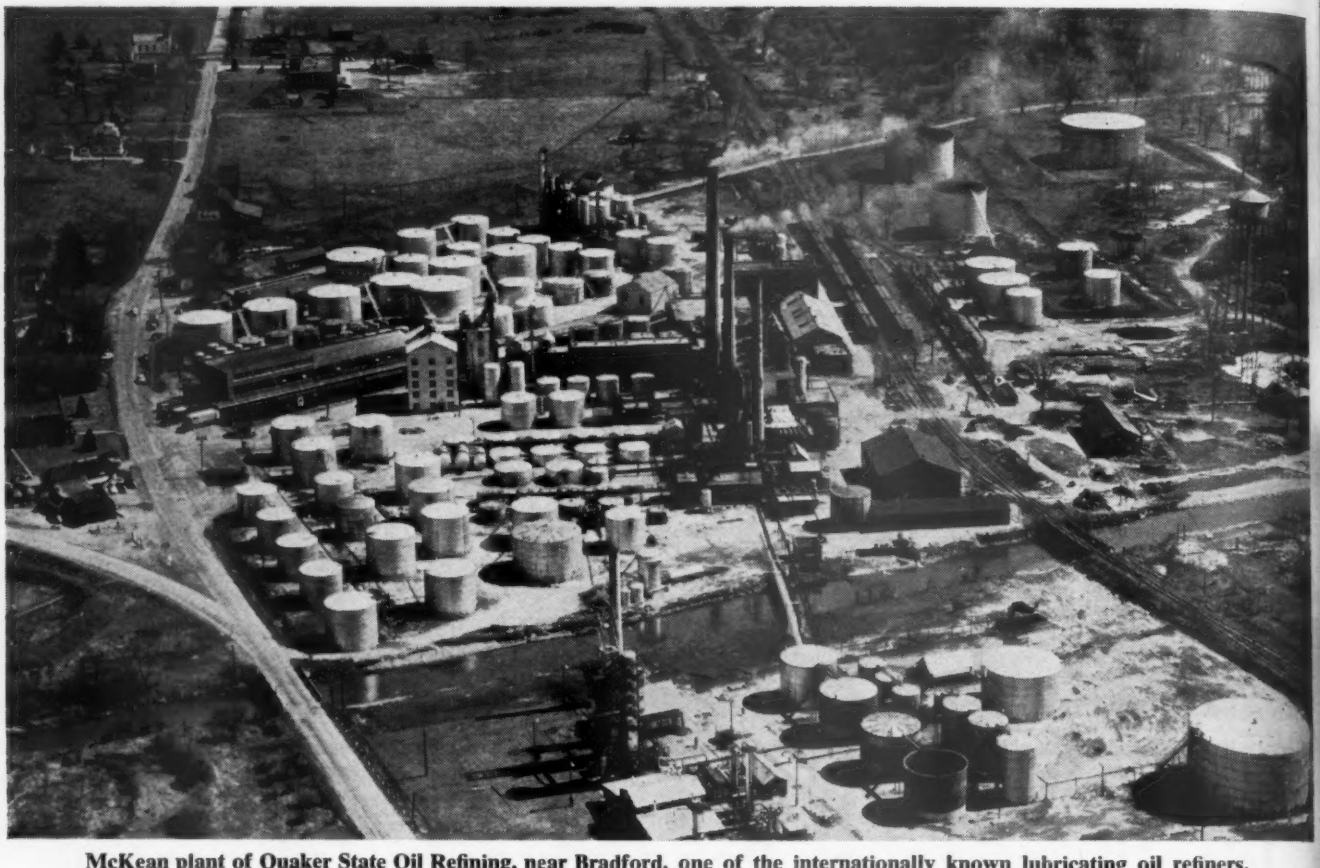
Analysis of such fractions is further simplified to a two-component system by the removal of the aromatics so that only the paraffins and naphthenes need

EXCLUSIVE

TABLE 1. Inspection properties of neutral oils studied.

Sample No.	Description	Crude Source	API Gravity	Viscosity SUS at 100 F	Viscosity SUS at 210 F	Viscosity Index	Pour Point, °F	Flash/Fire Point, °F	Color*
				Pennsylvania Oils					
1P	Pennsylvania 180	Buckeye	31.0	176.7	45.1	101.3	20	420	2.5
3P	Pennsylvania 180	Middle Dist.	31.6	185.1	45.8	103.1	25	420	D2.5
5P	Pennsylvania 180	Eureka No. 1	31.3	184.5	45.8	103.7	10	425	D2.5
7P	Pennsylvania 180	Bradford	30.3	182.9	45.6	101.8	25	425	D2.5
9P	Pennsylvania 180	Bolivar	29.8	181.03	45.05	95.2	20	425	3
13P	Pennsylvanio 180	Eureka No. 2 (Pa.)	30.8	186.3	45.85	102.8	25	425	2
17P	Pennsylvania 150, extracted	Buckeye (Pa.)	32.9	148.3	43.5	108.9	25	410	L2.
18P	Pennsylvania 150, extracted	Bradford (Pa.)	33.0	141.8	43.2	112.5	20	415	D2.5
85P	Pennsylvania long cut	Bradford (Pa.)	30.5	184.0	45.67	102.4	30	425	D2.5
S-9	Pennsylvania 150	Allegany (Pa.)	29.7	151.5	43.1	95	10	400/450	2.5
10	Commercial	Mid-Continent	30.3	207.9	46.6	92.9	0	425	L1.5
12	Commercial	Mid-Continent	31.6	174.8	44.8	98.5	5	420	D1
39	Commercial	Mid-Continent	30.3	208.4	46.6	93.0	0	410	D1
55	Commercial	Mid-Continent	26.9	153.8	42.3	67			
57	Commercial	Mid-Continent	31.0	165.3	44.2	99	-5	415/465	1.5
89	Experimental 100, dewaxed	West Edmond, Okla.	28.9	105.2	39.1	68.1			
108	Experimental	East Texas	24.0	280.2	48.3	61			
179	Experimental	West Texas	28.3	165.2	44.2	99	25		
40	Commercial	Texas	33.6	150.5	44.0	114.7	0	405	D1
203	Commercial 200	Louisiana	23.6	210.0	44.3	40	-35	370/430	
205	Commercial 200	Louisiana	23.3	200.0	43.3	10	-30	360/410	
15	Commercial 150	Gulf Coast	24.2	164.8	42.3	46.7	-10	360	D2.5
16	Commercial 275	Gulf Coast	23.3	286.6	47.7	44.7	-10	395	D2.5

* N.P.A. Color except as noted.



McKean plant of Quaker State Oil Refining, near Bradford, one of the internationally known lubricating oil refiners.

be considered. This type of information is the same then as has been obtained for the lubricating oil fraction; the major difference is the molecular weight and viscosity.

Refractivity Intercepts and Densities

A number of neutral stocks of known origin and history were selected. Although the number of oils covered by this study is not exhasutive, it is believed that it does include oils from all the fields from which appreciable amounts of lubricating oil are obtained. Moreover, the selection is far from representative in terms of quantity of production, as emphasis was placed on those non-Pennsylvania oils most like Pennsylvania oils in properties in order to show the differentiation obtained. The description and inspection properties of these oils are shown in Table 1 and the refractive indices and densities, in Table 2. The refractive indices were determined with a Valentine improved precision refractometer and the five-place densities were determined with a Becker density balance.

Study of the refractivity intercept and density values for the neutral oils

The Authors

Richard E. Putscher is a research analytical chemist with Armour Research Foundation. Putscher's experience in the analysis and composition of Petroleum began in 1939 with Universal Oil Products, where he was employed as an analyst for five years. Putscher was employed as shift supervisor in the control lab for aviation gasoline for Root Petroleum Company before joining Armour in 1945.

Mark Fred is senior chemist with the Argonne National Laboratory. A graduate of the University of Chicago with a Ph.D. degree in physics, Fred has worked as consultant to Standard Oil of Indiana and as a chemist with the Manhattan Project. He was formerly with Armour Research Foundation before joining Argonne. Fred has published some 25 articles and papers relating chiefly to spectroscopy and related fields.

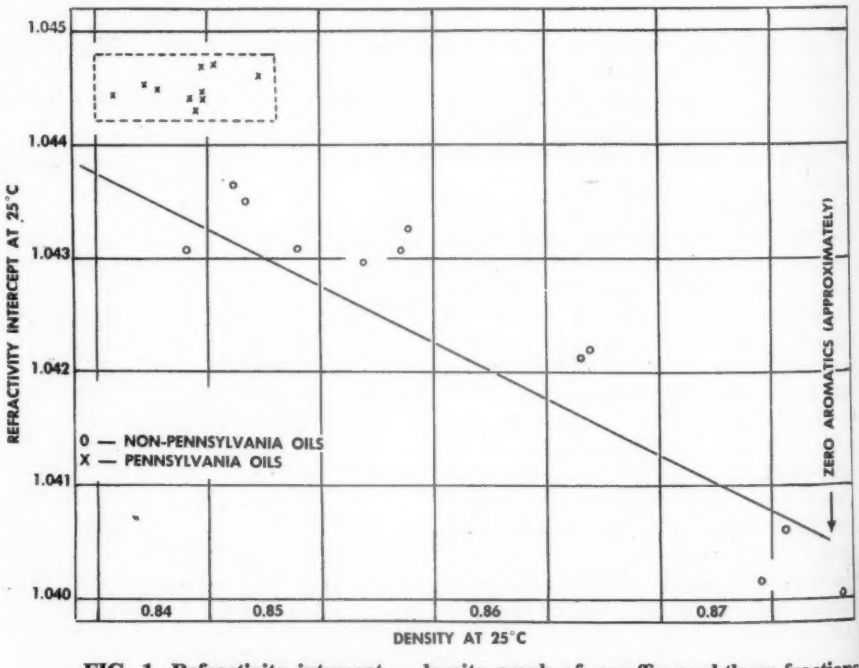


FIG. 1. Refractivity intercept — density graph of paraffin-naphthene fractions of neutral oils.

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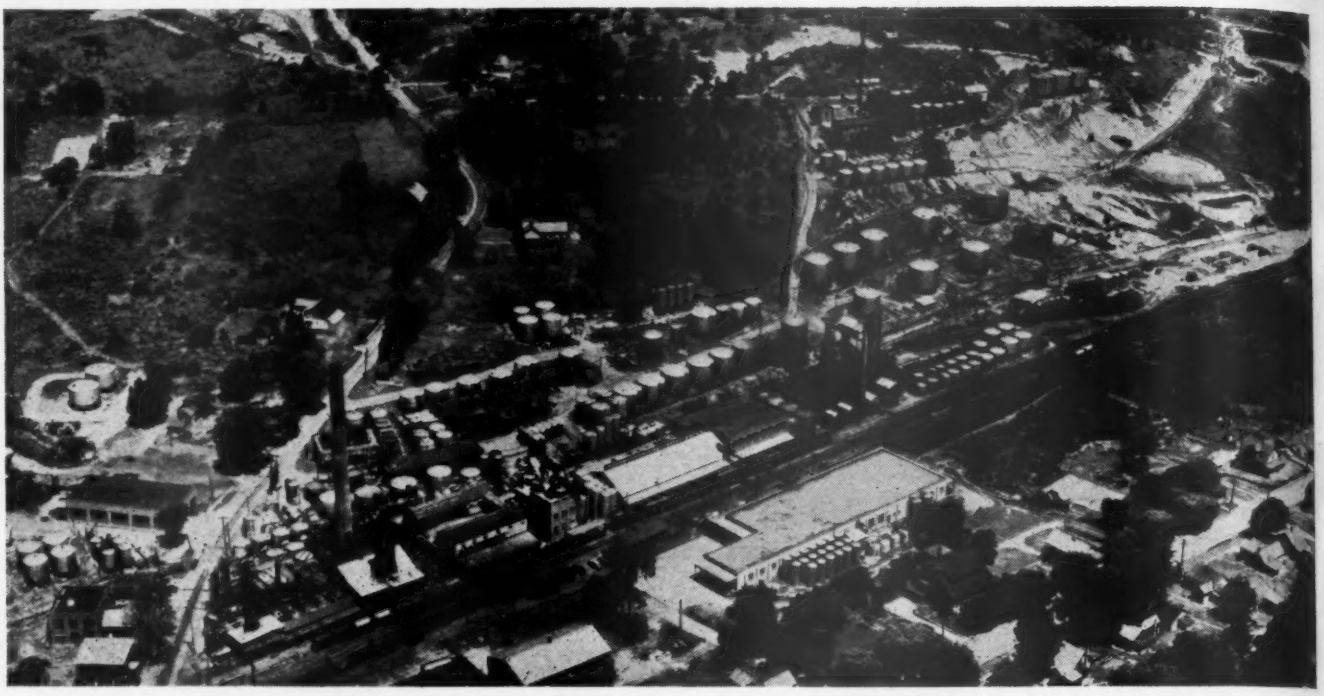

Plant of Pennsylvania Refining Company, Karns City, Pennsylvania, tucked away in Pennsylvania's green hills.

indicates that, although some correlation of values with crude oil source exists, there are some whole oils that closely resemble those from Pennsylvania. This is due partly to the natural variation of the aromatic content of oils and also to the varying extent of aromatic extraction performed in refining. Therefore, elimination of the aromatics from consideration is desirable. Probably the best procedure for doing this is by silica gel adsorption. Accordingly, the oils were separated by silica gel adsorption into the paraffin-naphthene and aromatics fractions; the aromatic fractions were discarded.

Data for paraffin-napthene fractions of the oils from silica gel adsorption are shown in Table 3, and the respective points are plotted in Fig. 1. The points representing the Pennsylvania oils have been enclosed by dotted lines.

TABLE 2. Physical properties of whole oils.

Sample No.	n_D^{25}	d_4^{25}	Refractivity intercept
	Pennsylvania Oils		
1P	1.48006	0.86431	1.04790
3P	1.47933	0.86357	1.04754
5P	1.47908	0.86289	1.04763
7P	1.48168	0.86673	1.04831
9P	1.48454	0.87132	1.04888
13P	1.48041	0.86506	1.04788
17P	1.47409	0.85598	1.04610
18P	1.47383	0.85532	1.04617
85P	1.48191	0.86685	1.04848
S-9	1.48394	0.87016	1.04886
	Non-Pennsylvania Oils		
57	1.47670	0.86450	1.04445
10	1.47656	0.86730	1.04291
12	1.47395	0.85976	1.04407
39	1.47894	0.86802	1.04493
89	1.48809	0.87650	1.04984
55	1.49371	0.88728	1.05007
40	1.46967	0.85120	1.04407
108	1.50521	0.90578	1.05232
179	1.48992	0.87874	1.05055
203	1.50014	0.90464	1.04782
205	1.50516	0.91410	1.04811
15	1.49722	0.90098	1.04673
16	1.50135	0.90760	1.04755

All of the non-Pennsylvania lubricating oils are represented by points well outside the dotted rectangle. The closest points for non-Pennsylvania oils are for oils commonly regarded as somewhat similar to Pennsylvania oils.

At the present time limits indicated in Fig. 1 (density from 0.8400 to 0.8480, refractivity intercept from 1.0442 to 1.0449) can be used to determine whether or not a sample of oil, within the viscosity range of a neutral, originates from the Pennsylvania Grade crude oil field.

TABLE 3. Physical properties of Paraffin-naphthene fractions.

Sample No.	Paraffin-naphthene fraction, %	n_D^{25}	d_4^{25}	Refractivity intercept
		Pennsylvania Oils		
1P	81.8	1.46735	0.84531	1.04470
3P	79.9	1.46683	0.84480	1.04438
5P	80.2	1.46655	0.84424	1.04443
7P	76.5	1.46695	0.84482	1.04454
9P	79.4	1.46826	0.84728	1.04462
13P	76.8	1.46658	0.84456	1.04430
17P	82.8	1.46586	0.84278	1.04447
18P	82.4	1.46565	0.84222	1.04454
85P	77.3	1.46707	0.84478	1.04468
S-9	72.4	1.46485	0.84083	1.04443
		Non-Pennsylvania Oils		
57	81.0	1.46893	0.85193	1.04296
10	92.6	1.47304	0.86191	1.04219
12	88.7	1.46985	0.85356	1.04307
39	76.5	1.47014	0.85386	1.04326
89	71.6	1.46509	0.84404	1.04307
55	64.8	1.46758	0.84900	1.04308
40	92.4	1.46685	0.84666	1.04352
108	61.3	1.47289	0.86154	1.04212
179	67.3	1.46668	0.84606	1.04365
203	67.6	1.47588	0.87056	1.04060
205	64.5	1.47830	0.87763	1.03949
15	67.2	1.47492	0.86950	1.04017
16	65.4	1.47710	0.87336	1.04042

TABLE 4. Reproducibility.

Sample No.	Paraffin-naphthene, %	n_D^{25}	d_4^{25}	Refractivity intercept
		Pennsylvania Oils		
1P	82.0	1.46753	0.84558	1.04474
1P	81.8	1.46735	0.84531	1.04470
5P	80.2	1.46655	0.84424	1.04443
5P	80.3	1.46654	0.84426	1.04441
13P	76.8	1.46658	0.84456	1.04430
13P	77.4	1.46694	0.84521	1.04434
		on-Pennsylvania Oils		
10	91.7	1.47315	0.86202	1.04214
10	92.6	1.47304	0.86191	1.04219
12	88.7	1.46985	0.85356	1.04307
12	88.3	1.46978	0.85347	1.04305
15	66.9	1.47492	0.86950	1.04017
15	67.2	1.47490	0.86949	1.04016

To show the reproducibility obtainable, a number of samples were run in duplicate to check the silica gel adsorption procedure as well as the refractive index and density measurements. Results obtained are shown in Table 4.

It will be noted in Fig. 1 that the paraffin-naphthene fractions from Pennsylvania oils are at a greater distance from the zero aromatic base line than the other oils. This difference can be accounted for by the presence of olefins which were shown to be present in the previously mentioned paper*.

The refractivity intercept provides another method by means of which it is possible to identify a refined lubricating oil as Pennsylvania or non-Pennsylvania oil. This can be done by means of two simple measurements, refractive index and density, which can be made with considerable precision. * * *

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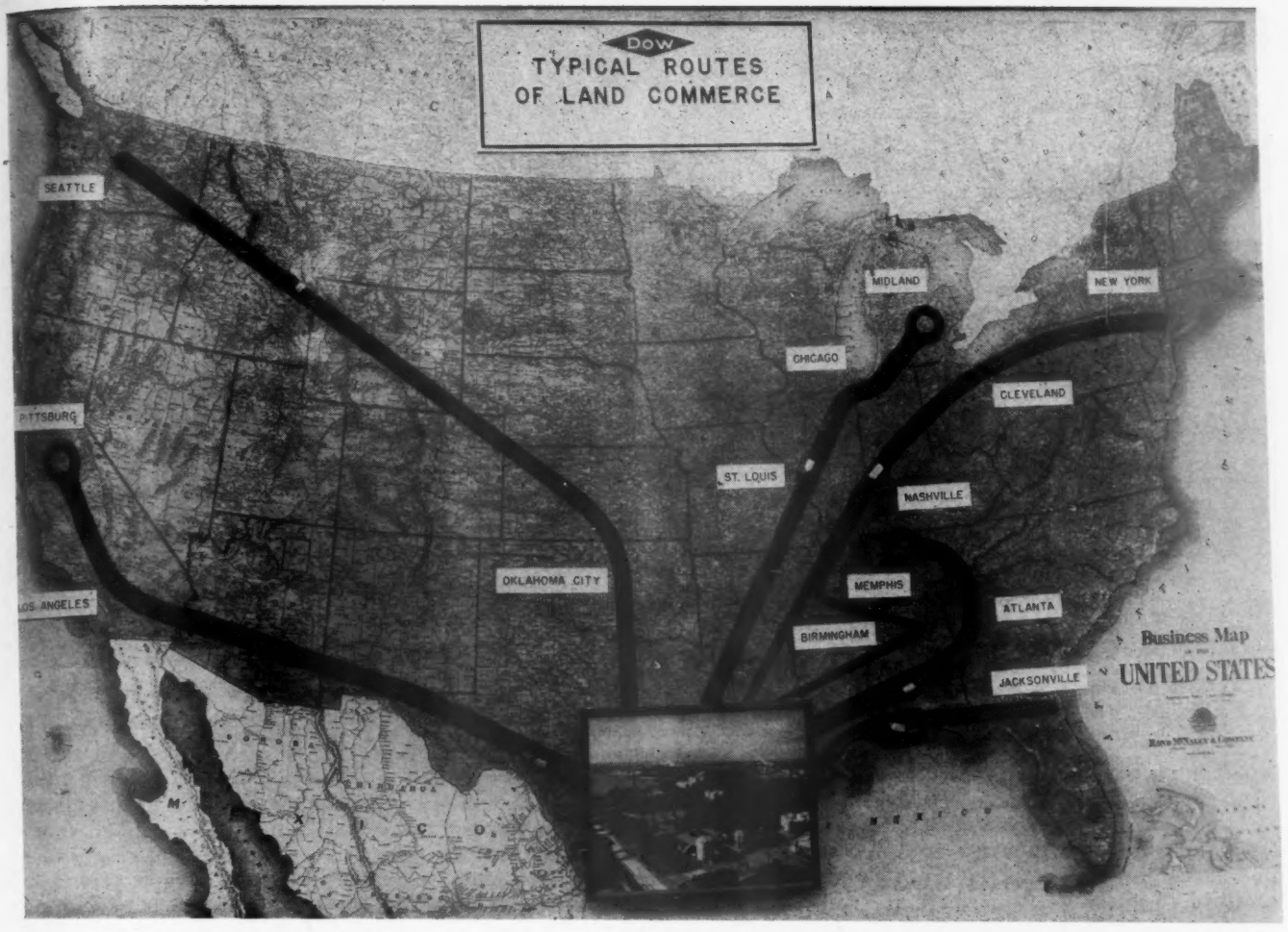

FIG. 1. Land routes of commerce make way for tanker transportation of voluminous liquid chemicals along seacoasts.
— (Wide World Photos)

Petrochemicals Become Seaborne

Major changes in transportation of bulk liquid intermediates signaled in launching of first chemical tanker

EUGENE B. BRIEN*

IN launching the first tanker ever built specifically for open sea transportation of bulk liquid chemicals in May, 1954, at Bayonne, New Jersey, Dow Chemical Company took cognizance of three major factors that are initiating a notable transportation change in the chemical and petrochemical industries.

Standard Oil (California) is reportedly following a similar line of thought by fitting an oil tanker for moving petrochemicals from its Richmond and El Segundo plants to its eastern and southern plants and raw materials from these sections to the West. Sun Oil may also be considering a similar move with retired tankers.

Three factors prodded Dow into this move: The great distances over which chemicals must be transported, vast quantities that must be moved, and the low cost at which final products are sold—usually in cents per pound. To be economic producing plants that use petroleum or natural gas as raw materials must be close to their raw materials—for a large section of the chemical industry, this means near the Gulf Coast. Finishing plants using the intermediates made from petroleum must be close to the large centers of population. (Fig. 1.)

For the first time, these three factors are economically handled with the launching of the Marine Dow-Chem, 23,000 ton, $8,000,000 tanker capable of holding 3,500,000 gal of 11 separate

EXCLUSIVE

*Eastern Editor.

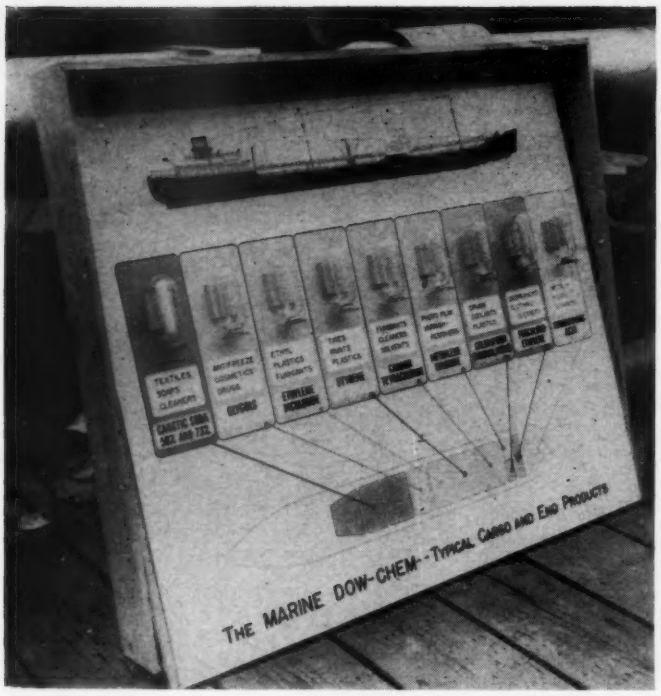

FIG. 2. Marine Dow-Chem, first tanker to carry liquid, bulk chemicals features unique system of cargo tanks.

FIG. 3. Visitors inspect nickel-clad cargo tank designed to hold 73 per cent caustic soda, a first in open sea transportation.

liquid products. The tanker's overall length stretches 551 ft, its beam spreads 68 ft, and its draft is 29 ft 7 in. It is driven by twin turbines and a 19-ft, four-bladed bronze propeller at a spread of 15 knots; its complement is 42 officers and men. (Fig. 1.)

The new tanker, scheduled to make over 20 round trips a year, will take on products at Freeport, Texas, and deliver them at first to five ports on the eastern seaboard from North Charleston, South Carolina, to Allyn's Point, Connecticut. At a later date, it is to call on Caribbean, Central, and South American ports.

Since 1949, the company has been gathering operating experience in open water transportation of bulk chemicals by operating a "pilot plant," the Marine Chemist, an oil tanker converted to transportation of chemicals. In completing 19 trips per year, the tanker provided the Shipbuilding Division of Bethlehem Steel, the builder, and Marine Transport Lines, the operator as well as Dow, the lessee, with the know-how to construct the first keel-to-mast tank ship for liquid products. The new ship is 87 ft longer, 4 ft wider, 25 per cent faster and 40 per cent larger than this older tanker.

Protective Measures

Differentiating the Marine Dow-Chem from any other tanker is the protective arrangements for its cargo tanks. Designed for chemicals whose purity is measured in parts per million, the ship is constructed with double bulkheads that provide two layers of steel between tanks and between tanks and the sea. Each product is further protected by its own individual transfer system (pipes, pumps, connections, vents). Because of this design, any or all tanks can be separately or simultaneously loaded or discharged without danger of contamination.

The tanker is the first American-built ship to overcome hull corrosion through cathodic protection. In metal exposed to water, a flow of current between the more and the less active spots of the metal is generated and the flowing electrons break down the metal at the more active spots. To overcome such breakdown, the designers bolted 60-lb magnesium anodes (being more electrically active than steel, magnesium carries the current) to carry the current instead of the hull in three groups of 30 anodes, forward, midship and aft. The magnesium should deteriorate but not the hull. To replace the anodes is a minor move compared to hull plates.

Corrosive Chemicals Require Special Protection

The Marine Dow-Chem was designed to transport hydrochloric acid, perhchloroethylene, methylene chloride, chloroform, carbon tetracholoride, ethylene dichloride, styrene, glycols and 73 per cent and 50 per cent caustic soda. Transportation of such highly concentrated caustic soda, for example, has never been attempted by sea because it is highly corrosive to steel and freezes at normal temperatures. To prevent corrosion, the two 52 ft by 40 ft caustic tanks, each holding 650,000 gal, are lined with 100,000 lbs of pure nickel. To prevent freezing, steam heating coils made of nickel maintain temperatures at 220 F; steam-traced pipe lines prevent solidification in loading or discharging. (Fig. 2.)

The tanker's two 39 ft by 48 ft, 35 per cent hydrochloric acid tanks, each holding 430,000 gal, are rubber lined to eliminate corrosion; loading lines are saran-lined and pumps are of carbon construction.

Products, sizes, and capacities of other tanks are: One 27 ft by 36 ft for carbon tetrachloride, 160,500 gal; one for cholorform, 25 ft by 48 ft, 430,000 gal; two for glycol, each 39 ft by 48 ft, 430,000; two for perchloroethylene, each 27 ft by 36 ft, 160,000 gal; and one Hortonspheroid tank for methylene chloride with a 210,000 gal to be held at 12 psi.

A leading pioneer in water transportation of chemicals, Dow originally was of material assistance in designing the first inland-waterway barge for transportation of hydrochloric acid. It was the first to undertake water-borne shipments of the chlorinated hydrocarbons, such as carbon tetrachloride, chloroform, methylene chloride, ethylene dichloride and styrene.

On the same occasion as the launching of the ship, the company also dedicated a 12 tank, 3,250,000 gal receiving and storing terminal to handle the chemical cargoes of the new tanker. The terminal also features a 58,000 gal tank for blending various grades of perchloroethylene and drumming facilities for filling and storing 55-gal drums of carbon tetrachloride and perchloroethylene. * * *

XUM

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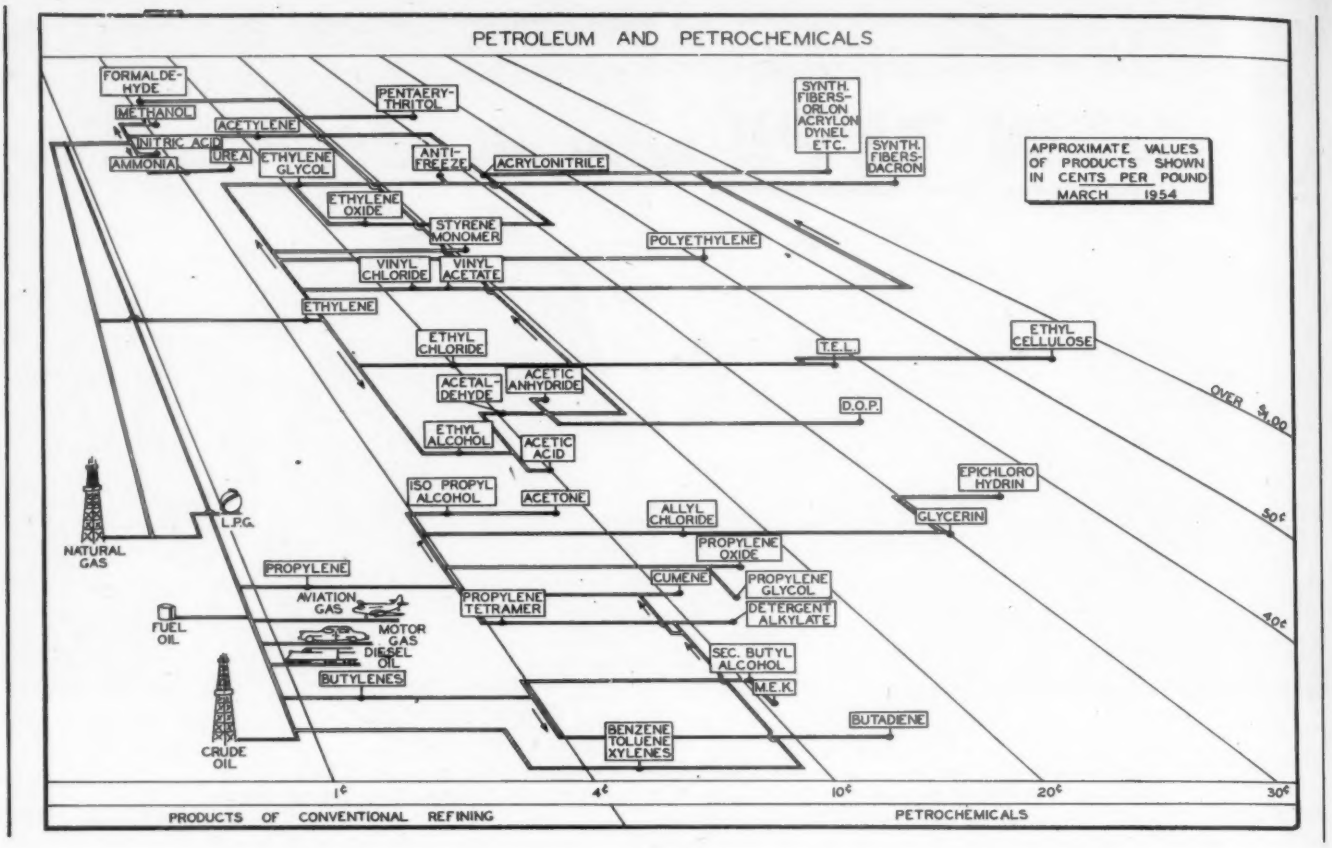

Fig. 1.

PETROCHEMICALS—

Glamor Girl or Problem Child?†

G. B. RYAN*
V. A. BREITENBACH*
H. K. NIEUWENHUIS**

Is everything in the petrochemical world ipso facto sweetness and light? If not, why not?

If we want to get into the business, how do we go about it? How far out must one stick one's neck?

It is the purpose of this article to discuss these questions. In so doing, we may raise other, more specific questions which can only be answered in the light of specific circumstances.

The first question was "Why are we interested?" Quick as a flash comes the answer "Because petrochemicals come from petroleum, and we are in the petroleum business." If this were the whole answer, it would be a sad commentary on the enterprise of the oil industry. What have we been doing for the past 25 years? Furthermore, consider that the biggest operator in petrochemicals today is not a petroleum company. Among the latest and more spectacular arrivals in the field we find a whiskey company, a railroad tycoon, and a bunch of investment bankers.

Nevertheless, the pat answer is a good enough one in many instances. As refiners, we are in the business of upgrading our raw material into more valuable products. This objective can well lead us into petrochemicals. Fig. 1 is an attempt to illustrate why.

This rather complicated looking diagram was drawn up in an attempt to help us orient ourselves with respect to prices of petroleum and petrochemical products. The more or less vertical lines fanning out from the upper left corner divide the chart into cent per pound areas. Over in the area below one cent are our raw materials—natural gas, heavy fuel, crude oil, In the one to four cent range, we find most of the familiar petroleum products.

Ranged out along the 4-cent line are the common, big-volume petrochemicals—methanol, ammonia, ethylene, tetramer, aromatics. From there on out, we proceed through things like vinyl chloride, at 10 cents; proplyene oxide, at close to 20 cents; acrylonitrile, in the 30 to 40 cent range; syn-

*Standard Oil Company (Ohio).
**Chemical Projects Associates.
†Presented before the 19th Mid-Year Meeting of the American Petroleum Institute's Division of Refining, Houston, Texas, May 12, 1954.

thetic fibers, up in the "over $1" category. Such ultra-glamour products as hydrazine—at around $3—would be way off the chart.

Looking at this chart, it would appear hardly possible to make any chemical from crude oil that wouldn't sell for more than our present products. So petrochemicals is a natural field to look at for upgrading our raw materials or by-products.

Another answer could be the romance—the glamour. This is not so silly as it might seem. It's the romance that attracts the investment banker. It's the romance that prompts questions at stockholders' meetings. Many of you have seen the change that takes place in the countenance of a stockholder when someone mentions petrochemicals. He breaks into a broad grin and his eyes open up like $ilver dollar$. This glamour is measured in terms of profit potential, growth, and return on investment. Certainly this a good enough reason for anyone.

A final reason for our interest could be fear. There are at least two kinds of fear that could be involved. The first, and more substantial kind, is the fear that one's competitors are making a lot of money in chemicals, and that some of these profits will (perish the thought!) be used to subsidize their gasoline business. One could end up with no business at all.

A second way in which fear is manifested is via what might be termed "the scare approach." Many of you have seen this used in an attempt to "sell" the oil industry on petrochemicals. For example, if we were selling anything, and if we wanted to use this approach, we would make reference to RCA's announcement of the atomic battery, accompanied by some such cliche as "Mark ye well! This spells the beginning of the end for the gasoline business!" When delivered in a "crack of doom" voice, this technique can be quite effective.

The scare approach, however, is rather thin. We are all ready to admit that the demand for gasoline will come to an end some day. But we are refiners—manufacturers. We make energy sources in easily marketable form. If atoms is what they want, atoms is what we'll give them. There's undoubtedly a lot of wishful thinking in this, but if we look hard enough, we can find better reasons than fear for our interest in petrochemicals.

The second basic question was "Is everything in the petrochemical world ipso facto sweetness and light? The answer to this question can be illustrated by reciting just a few of the names that have already left their mark on the industry—Shell, Oronite, Phillips, McCarthy, R.F.C., Metropolitan Life Insurance Company. We'll have to admit, though, that very few shirts have been lost permanently by people who paused to think before tossing their last buck into a petrochemical venture.

The pitfalls that may cause headaches for a new arrival on the petrochemical scene are, we believe, most likely to be associated with certain basic differences between the gasoline business as we know it, and the petrochemicals business as we see it from the outside looking in.

Roughly, some of the more important of these differences as in the following areas:

1. **Volume**
2. **Type of competition and markets**
3. **Capital requirements**
4. **Risk and return**

There are many other differences which will immediately occur to some of you, especially to those small, mean, and captious people who resent being lectured by a non-expert. This article, however, is going to discuss those four areas, the nature of the basic differences, and some of the possible implications for a company not yet wholeheartedly committed to a petrochemical venture.

Number one on the list, differences in volume, is the most obvious. It is so obvious, in fact, that many un-initiated non-experts flatly refuse to discuss any of the other differences, considering this one to be the total answer.

One of the biggest petrochemical operations in the U. S. today, when converted to refiner's language, amounts to something like 13,000 bbl per day—barely 3 per cent of the parent company's refinery throughput. There is no denying that, even to a small refiner, production of petrochemicals will always seem something of a side-line as far as actual physical volume is concerned.

Dollar volume is something else again. In the example just cited, that 3 per cent of refinery throughput accounted for 10 per cent of the parent company's total dollar sales. Thus, while it may be a side-line to the throughput-conscious refinery operator, it is not "chicken-feed" to the profit-minded management or stockholder.

Depending upon the organization and personnel with which a company is saddled or blessed, this physical volume difference may dictate certain organizational requirements for the petrochemicals business. For example, a petrochemical venture carried out as part of an existing refinery operation, being "small stuff," may suffer from neglect on the part of the plant management. On the other hand, the petrochemical operation is more romantic—it has "sex appeal"—particularly for the technical man. Thus, the gasoline business could be the one that is neglected.

It is probably possible to integrate the petrochemical manufacturing operation into an existing refinery structure. Indeed, several companies have done it, and are well satisfied with the result. Others have tried it and given it up. The implications of the volume differences are something to think about in any event. There are no foregone conclusions.

The second area of difference we suggest for preliminary consideration has to do with competition and markets.

In any chemical business, competition is apt to be most intense at the manufacturing step, with sales competition pegged on technical know-how and novelty rather than service, clean rest rooms, and loud advertising. This difference makes for a vastly different frame of mind and organization. Eventual emphasis may be on secret processes and patents. Research and development budgets may be all out of proportion to those we are familiar with in the gasoline business. Existing sales organizations and personnel may be of little or no help.

As most oil companies have had experience with every kind of commercial, institutional, and private customer, they are not liable to run into anything new in this respect. In the petrochemical field, however, the markets are apt to be less restricted geographically, even though location of plant facilities is more of a competitive factor because of lower volumes and consequent greater freight charges.

The oil company man looking at petrochemicals will find markets changing more rapidly. They not only grow faster (in both directions—up and down) but are apt to change location and significance. He will find that timing is of first importance, and he has to know a lot more about the present and future needs of his customers—not just as to quantity and quality, but as to kind. He will have to engage in what might be termed "market research and development" instead of the "marketing research" with which he is familiar.

The former may be concerned with actually developing a demand for something he can supply, whereas the latter was concerned with finding better methods to supply an old, well understood demand. The former needs to be closely allied with scientific research and development and requires entirely different talents and training.

The third area has to do with capital requirements. Here the differences are

not so pronounced or apparent. Comparing on a dollar volume basis, capital requirements for actual production equipment may not be much different from those with which refiners are familiar, at least insofar as the large-volume petrochemicals are concerned. Requirements for working capital, however, are a different story. Limitations on storage of raw materials which are often gaseous, may indicate large inventories of high value products. In some cases total capital requirements will be many times higher than for the gasoline business, when comparing on a sales volume basis.

The last area for consideration was that of risk and return. It is these two "R's" of course, that makes up the third one—Romance. There is no denying that the chemical business is less stable, more risky than the gasoline business. The risks can be minimized, but not without also minimizing the return.

Actually, the field of petrochemicals offers an extremely wide range of risks. You can start off by using known processes to produce known products for which there is an existing market in which you have determined you can compete. This is the least risky method. The return on capital may not be much, if any, greater than you have been getting in the gasoline business. This method, however, provides an opportunity to get your feet on the ground in a new and unfamiliar business.

The greatest risks, and the really big pay-offs, come from taking chances on new products or processes that result from one's own research work. In spite of the progressive nature of oil refining, there are many more opportunities for new products and processes in the petrochemical industry. Nevertheless, because of other differences discussed before, this is probably not a recommended starting procedure for the neophyte.

Between these two extremes there are, of course, myriad degreees of greater or lesser risk.

Summing up this brief discussion of risk element, it can be said that petrochemicals offers a wide-awake management an opportunity to take risks greater than those it is used to, and reap correspondingly larger returns on its investment. An alert management will not be so concerned with minimizing the risk as it will be with maximizing its knowledge of the risk before taking it. There's a world of difference between gambling and taking a calculated risk—just as there's a world of difference between McCarthy and Shell Chemical.

This leads naturally into a discussion of the third question propounded back at the beginning of this article. That was "How do we go about getting into the business?"

Of course, there's no substitute for being lucky. Probably we can agree that, if you know you're going to be lucky, you should just dive head first into the first petrochemical operation that catches your fancy.

Some of us, however, are not as gifted as others. Whenever we are dealt four of a kind, we have to assume that the guy across the table (who drew three) filled an inside straight flush.

There are other shortcuts to success. Like buying up a company that is already in the business. This is recommended for such filthy-rich people as movie stars, crude oil producers, dope peddlers, and so forth. But even if you can afford such luxury, you're not really in the petrochemical business. You're simply an investor. Maybe you'd do just as well by putting your money into Standard of California stock. Some variations on this technique, however, are commendable. Such as buying up your competitors' customers. This has been practiced quite frequently in recent years.

For the ordinary refiner, however, these approaches are not usually practical. The best bet for such a company is to take a good, long look at each aspect of each prospective venture. Clean the make-up off the glamour girl. Strip her down to bare essentials. You may find glamour isn't even skin deep.

On the other hand, she may lose her glamour and turn into a good, steady homebody. Not so exciting, but a pretty good bet just the same. Or maybe she'll still have her glamour, it may be real. You still may conclude "You can have her, I don't want her, she's too fast for me."

Summing up again, we don't think there is a substitute for the study and planning approach. This is really what we have been talking about all through the article.

We have presented our views on some aspects of petrochemicals which we believe should be understood by any oil company management. We have discussed certain differences that exist between the gasoline business and the petrochemicals business. It has probably seemed like a rather routine presentation of a series of known propositions. This is not surprising, because that is what it was.

Lest you feel entirely imposed upon, however, we hasten to remind you that you were spared the old platitudes involved in a definition of petrochemicals. And you were also spared the usual razzle-dazzle presentation of extrapolated Paley Report statistics wherein everything is projected (based on population) to stratospheric levels.

Isobutylene Separation With Sulfuric Acid†

Ninety-six per cent isobutylene recovered from stream containing fourteen per cent

G. P. BAUMANN*
and M. R. SMITH*

IN the petroleum industry the earliest application of the reaction of *iso*butylene with sulfuric acid was the cold-acid polymerization process, which was first used commercially in the early 1930's. The dimer from this process was hydrogenated to produce the key ingredient in the first high-octane (100) aviation gasoline made by the industry.

The manufacture of *iso*butylene consists of extraction of *iso*butylene with 65 per cent by weight of sulfuric acid and regeneration to separate the *iso*butylene from the acid. These reactions are carried out under specific operating conditions so as to enhance the desired reactions at the expense of undesired side reactions. The combined extraction-regeneration process was developed by Standard Oil Development Company, and has been practiced commercially since 1942. It is available to the industry under appropriate licensing arrangements.

This process is cheaper, and it gives a higher yield of *iso*butylene, than the previously practiced process of extract-

*Standard Oil Development Company, Linden, New Jersey.

†Presented by M. R. Smith, to a session on petrochemicals before the American Petroleum Institute's Division of Refining, Houston, Texas, May 12, 1954.

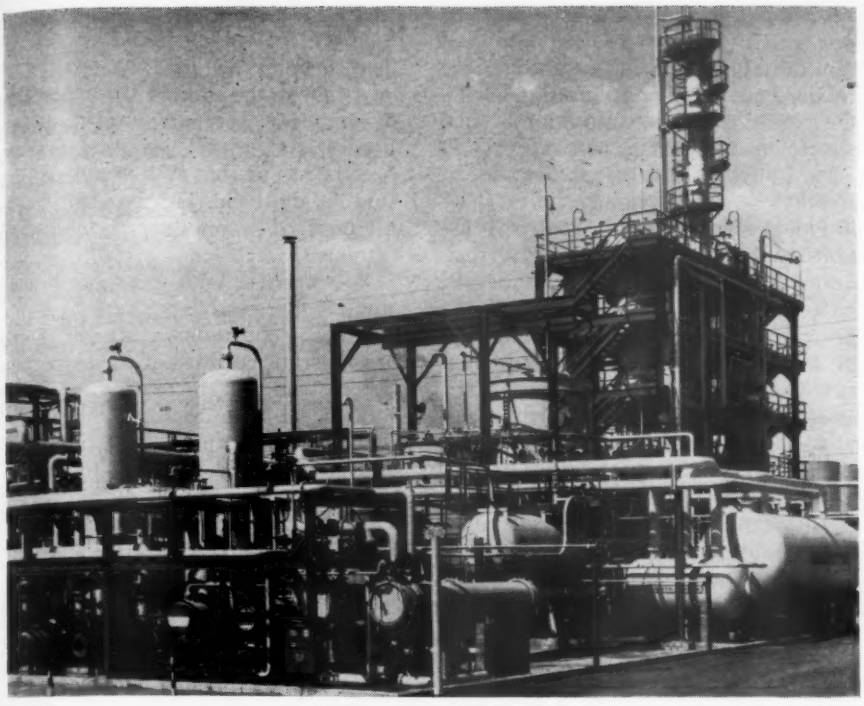

FIG. 1. View of isobutylene extraction-regeneration unit.

ing *iso*butylene with sulfuric acid, recovering the *iso*butylene from the acid extract as a polymer (dimer-trimer mixture), and cracking the polymer to *iso*butylene.

Principal impetus for development of this process was the great demand for synthetic rubber prompted by World War II. Its principal application has been the production of feed stocks for synthetic-rubber manufacture—the *iso*butylene for butyl rubber (a high molecular-weight copolymer of *iso*butylene and isoprene), the *iso*butylene-free raffinate for Buna-S (GR-S) rubber. The raffinate is generally concentrated by normal or extractive distillation prior to dehydrogenation of *n*butylenes to produce butadiene.

The original commercial *iso*butylene manufacturing plants built through affiliates of Standard Oil Company (New Jersey) are part of U.S. and Canadian government-owned synthetic rubber plants. The most recent plant built by an affiliate of Standard Oil Company (New Jersey) is located at the Bayway (Linden, New Jersey) refinery of Esso Standard Oil Company. It went on stream in August 1953.

In the discussion which follows the process is described along more or less general lines.

Description of Process

The two critical requirements for design and operation of an *iso*butylene plant are yield and selectivity. A high yield of *iso*butylene is important from the point of view of maximizing utilization of available *iso*butylene. In cases where the raffinate is used for secondary butylalcohol manufacture it is necessary to produce an essentially *iso*butylene-free raffinate; thus a high yield of *iso*butylene is important, in that it reflects a high degree of removal (or cleanup) of *iso*butylene from the raffinate.

Selectivity refers to the preferential absorption of *iso*butylene while the absorption of normal butylenes is minimized. Absorbed normal butylenes would be released with the *iso*butylene in the regeneration section and would show up as an impurity in the final product.

Side reactions or effects which have an adverse effect on yield and/or selectivity are:

1. Absorption of *n*butylenes.
2. Formation of polymers in either the extraction or regeneration steps.
3. Loss of tertiary butyl alcohol in the raffinate.
4. Regeneration of tertiary butyl alcohol as such (the alcohol is recycled, and too great a recycle stream could reduce plant capacity).

Operating conditions are selected so as to minimize the foregoing.

The basic steps in the manufacture of *iso*butylene using sulfuric acid are the following:

1. **Extraction.**
2. **Regeneration.**
3. **Scrubbing and compression.**
4. **Acid concentration.**

Each of these steps is shown schematically in the simplified flow plan in Fig. 2. In the extraction section fresh feed is contracted countercurrently in 2 stages with 65 per cent by weight of sulfuric acid. Spent butane (raffinate) is withdrawn from the second stage, and final rich extract from the first stage. Extract is fed to the regeneration system, where it is diluted to 45 per cent and heated. *iso*butylene is regenerated as a gas at low pressure. The 45-per-cent acid is reconcentrated to 65-per-cent, and then is cooled and recycled to the extraction section. The *iso*butylene gas is scrubbed with caustic, cooled to condense alcohol and polymer, water-washed to scrub out traces of alcohol, and then compressed and condensed.

Each of the main steps is described in the following sections, along with a discussion of the principal process variables.

Extraction

The feed stock is a closely fractionated liquid butane-butylene stream

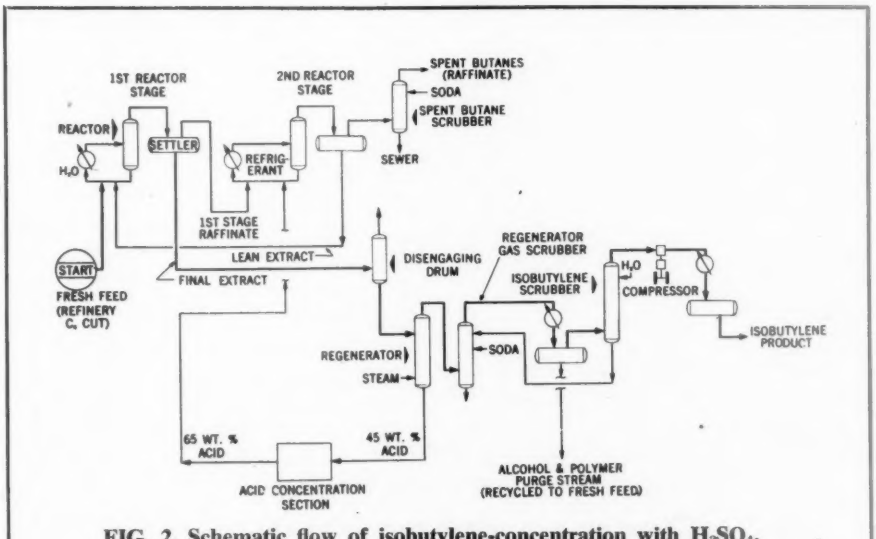

FIG. 2. Schematic flow of isobutylene-concentration with H_2SO_4.

which is treated with 65 per cent by weight of sulfuric acid for preferential chemical extraction of *iso*butylene. The hydrocarbon and acid are intimately mixed and allowed to settle into two phases; the upper phase is the raffinate (spent butanes), and the lower phase is the acid extract.

The amount of *iso*butylene extracted, and its subsequent purity, are primarily fixed by the extraction conditions. The important variables are:

1. Acid strength.
2. Temperature.
3. Holdup time.
4. Extract saturation (moles of *iso*-*iso*butylene per mole of 100-per-cent sulfuric acid).
5. *Iso*butylene content of feed.
6. Number of treating steps.
7. Mixing intensity.

Acid strength is maintained at 65 per cent by weight. Higher acid strengths decrease selectivity, increase loss of *iso*butylene to polymer, and unduly raise the acid-reboiler duty. Lower strengths greatly increase corrosion of steel equipment. Temperature is important because an increase in temperature increases the equilibrium concentration of *iso*butylene in the raffinate, both as *iso*butylene and tertiary butyl alcohol. A rise in temperature increases the extraction rate of both *iso*butylene and normal butylenes, and also increases the rate of polymer formation.

Inasmuch as the rate of extraction is a function of temperature and extract saturation, holdup must be sized to allow sufficient time for the necessary reaction to be carried out. The extraction rate is also a function of mixing intensity. Adequate mixing is readily provided by well-known methods. Final extract saturation is important in setting the acid rate and, hence, in sizing the acid-concentration facilities. A high-extract saturation is desirable in minimizing acid rate. It results, however, in a larger amount of *iso*butylene in the raffinate.

Fig. 3 shows the equilibrium relationship between extract saturation and *iso*butylene concentration in the raffinate for parameters of temperature. Thus it can be seen that high cleanup of *iso*butylene can be obtained only at low temperatures or with low extract saturation. Fig. 4 shows the relationship of temperature on *iso*butylene-extraction rate for parameters of extract saturation.

This relationship shows that high temperatures are necessary to have relatively fast extraction rates. Thus high cleanup and high extraction rates cannot be carried out simultaneously in one reaction stage in order to produce an extract of high saturation. A two-stage process, however, which is operated countercurrently with the second stage operating at a lower temperature, will produce high cleanup; whereas the first stage, operated at higher temperature, gives high final extract saturation and relatively high extraction rates.

The phase distribution for tertiary butyl alcohol, which is present in the extraction system, follows a pattern similar to *iso*butylene. Higher temperatures and extract saturations give greater concentration of tertiary butyl alcohol in the spent butanes. By withdrawing final raffinate from the low-temperature—low-saturation stage, loss of *iso*butylene as alcohol in the raffinate is minimized. Under normal conditions the alcohol content of the raffinate will be on the order of 0.1 per cent by liquid volume.

Although the equilibrium absorption of *n*butylenes is relatively high, extraction rates of *n*butylenes average about one-sixtieth of that of *iso*butylene. Excess holdup time is avoided so as to limit the amount of *n*butylene extracted.

Polymer loss with the spent butane amounts to about 1 per cent by liquid volume of the raffinate stream. Some of this is formed within the extraction system, amount increasing with increased temperature and holdup time. Remainder is formed in the regeneration step, and is returned to the extraction section by a purge stream which will be referred to later.

In the 2-stage operation, as shown in Fig. 2, fresh feed and lean extract (approximately 0.5 saturation) are fed to the first stage, which is maintained at a temperature of approximately 100 F. Heat of reaction is removed by cooling water. The resulting rich extract (approximately 1.5 saturation) formed in the first stage is sent to the regeneration step.

The partly spent hydrocarbon phase is cooled and extracted with 65 per cent by weight of sulfuric acid, at a temperature of approximately 55 to 75 F, to remove essentially all but the equilibrium amount of *iso*butylene in the hydrocarbon phase. This temperature is maintained by refrigeration. The resulting lean extract is pumped to the rich extract stage. Before it is sent to storage, the final raffinate is caustic-washed for removal of entrained acid and acid formed by breakdown of acidic compounds.

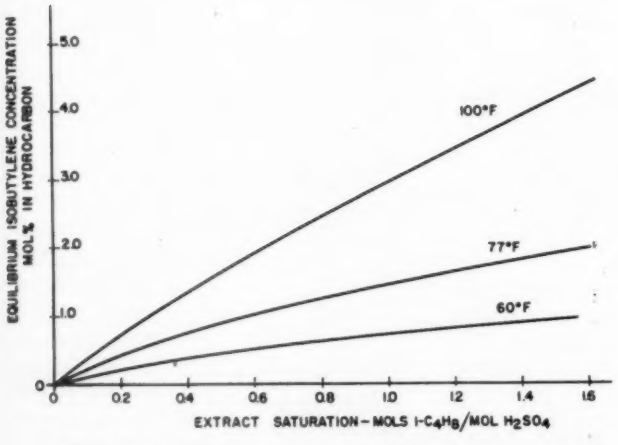

FIG. 3. Equilibrium curves of isobutylene in hydrocarbon and extract of 65 wt per cent of sulfuric acid.

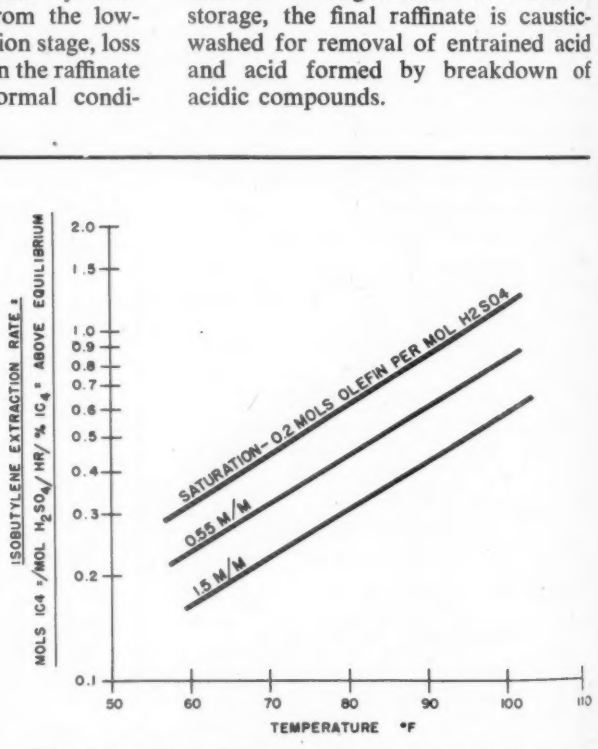

FIG. 4. Specific extraction rate: isobutylene in 65 wt per cent sulfuric acid.

Regeneration

The final acid extract from the extraction section is degassed, and then is fed to the regenerator. In the regenerator three reactions can be carried out, depending on operating conditions, as follows:

1. Isobutylene in extract to isobutylene.

2. Isobutylene in extract to tertiary butyl alcohol.

3. Isobutylene in extract to dimer and trimer polymers.

Under proper conditions the first reaction predominates, and 90 per cent of the *iso*butylene in extract can be regenerated as *iso*butylene on a once-through basis. Recirculation of alcohol and polymer is normally carried out so that the overall yield of *iso*butylene is 95 per cent. This high yield is obtained because alcohol will enter the extract phase, and *iso*butylene can then be regenerated as mentioned previously. Thus only a very small amount of *iso*butylene leaves the unit as alcohol. The dimer and trimer do not convert back to *iso*butylene, however, and *iso*butylene converted to polymer in the extraction or regeneration step is lost as such.

The principal process variables in regeneration are:

1. *Pressure.*
2. *Bottom temperature.*
3. *Acid strength.*

Optimum pressure is close to atmospheric. Lower pressure favors the production of alcohol, and higher pressure favors the production of polymer. In general, polymer formation increases with increasing temperature. Increasing the strength of the acid increases polymer formation; decreasing the strength of the acid favors alcohol production, and also increases the heat load of the acid concentrator unduly. All these variables are interrelated; for example, a change in either acid strength or pressure affects operating temperature.

Steam added to the regenerator bottoms has the following functions:

1. Dilute the acid to 45 per cent by weight.
2. Heat the acid.
3. Provide heat for the endothermic regeneration reactions.
4. Strip reactants and reaction products from the acid.

The amount of steam is adjusted to provide the necessary heat and water balance so that the amount of steam in the overhead vapors is minimized. The concentration of steam in the overhead vapors sets the temperature, and also the effective hydrocarbon partial pressure under which the *iso*butylene is regenerated. Presence of excessive steam in the overhead vapors lowers the hydrocarbon partial pressure, and has the same effect as lowering total pressure on the system.

The regeneration tower may be packed or constructed with trays. Although the rate of regeneration is not instantaneous, the use of trays provides sufficient holdup time for completion of the reactions. The amount of hydrocarbon in the acid bottoms is normally zero to a trace amount.

Scrubbing and Compression

The vapors which leave the top of the regenerator contain the following:

1. Steam.
2. *Iso*butylene.
3. Tertiary butyl alcohol.
4. Polymer.
5. Acid mist.
6. Traces of *n*butylene and secondary butyl alcohol.

These vapors are first scrubbed with hot caustic-soda solution to remove acid mist. Vapors from the caustic scrubber are then cooled to condense most of the alcohol and polymer. This condensate, an alcohol-polymer-water solution, is returned to the extraction section. The remaining vapors disengaged from this condensate are fed to a final water scrubber for cleanup of alcohol. The *iso*butylene vapors from this scrubber are compressed, and then condensed.

Acid Concentration

The regenerator-bottoms liquid is boiling sulfuric acid (strength, 45 per cent by weight), and it is gravitated to the acid reboiler where water is evaporated to increase the acid concentration back to 65 per cent by weight. This operation can be carried out in an atmospheric or vacuum acid reboiler.

TABLE 1. Typical feed and product stream anaylses.

Stream	Feed	Iso-butylene	Spent Butanes
Component (liquid volume) per cent:			
Propane-propylene	2.0	0.0	2.3
nButene-1	11.0	0.4	12.6
cisButene-2	10.0	0.5	11.4
transButene-2	7.0	0.4	8.0
Isobutylene	14.0	96.0	1.2
nButane	23.0	0.6	26.1
Isobutane	31.0	0.1	35.4
C_5+	2.0	2.0	3.0
Total	100.0	100.0	100.0

The hot 65-per-cent acid is cooled, and then pumped to the lean (second) stage reactor—thus completing the cycle.

The acid to the concentrator contains a very small quantity of hydrocarbon. Because the acid is at relatively high temperature in the concentrator, there is some breakdown of hydrocarbon to form carbon. The carbon buildup should not be allowed to become excessive.

Feed and Products

The feed stream to the unit is well-fractionated butane-butylene refinery cut. A typical feed stream in a refinery with thermal and catalytic cracking would have an analysis as given in Table 1. Typical analyses of the spent butanes and *iso*butylene products are also given in Table 1. For this feed stock and a 2-stage extraction step, 85 per cent of the *iso*butylene in the feed has been extracted and regenerated to *iso*butylene.

Corrosion and Materials

Although the process uses corrosive chemicals, the corrosion problems are limited to a relatively small number of locations in the plant.

In the regeneration and acid-concentration sections—where hot, dilute sulfuric acid is handled—special construction materials are required.

TABLE 2. Economic data on Isobutylene manufacture.

Plant capacity:	
Isobutylene product, short tons per calendar day	80
Feed, barrels per calendar day	6,300
Spent butanes, barrels per calendar day	5,550
Plant investment—onsite*	$2,000,000
Plant service factor, per cent	90
Operating labor, men per shift	3
	Per barrel of feed
Chemicals:	
Sulfuric acid (strength, 100 per cent), pounds	0.25
Caustic soda (strength, 100 per cent), pounds	0.15
Propane, gallons	0.05
Utilities:	
Steam (from and at 212 F), pounds	90
Power, kilowatt hours	4
Cooling water (at a temperature of 87 F), gallons	700
Fresh water (condensate), gallons	5

* Gulf Coast location.

Investment Cost

The onsite investment cost for an *iso*butylene plant which has a capacity of 80 short tons per calendar day is estimated to be approximately $2,000,000 for a Gulf Coast location. The plant for which this investment cost applies is sized to handle 7000 bbl per stream day of feed stock which contains 14 liquid-volume per cent *iso*butylene, and to make a product of 96 per cent liquid volume of purity. This investment includes refrigeration facilities. If refrigeration is obtained from a central offsite system, the onsite investment would be correspondingly less.

Labor—Chemicals—Utilities

Operating labor, chemical consumption, and utility requirements are shown in Table 2. Chemicals and utilities are given per barrel of feed. No attempt has been made to work up typical operating costs, inasmuch as these would vary widely depending on local conditions.

Use of Sulfur Dioxide for Extracting Benzene & Toluene†

Use of a wash oil in the extraction tower and a Methanol Azeotrope yields high purity aromatics

R. A. RATLIFF* and W. B. STROBEL**

PURPOSE of this article is to review the operation of a commercial sulfur-dioxide extraction process which is unique in three respects, as follows:

1. High recoveries of benzene and toluene-xylene fractions, which have been extracted simultaneously, are obtained.
2. Only one stage of separation is needed to remove sulfur dioxide from the raffinate.
3. Methanol is utilized for the azeotropic separation of non-aromatics from benzene.

The process scheme employed by Continental Oil Company in the Lake Charles, Louisiana, refinery for the simultaneous extraction and purification of benzene and toluene is a sulfur-dioxide solvent extraction modified for utilization of a hydrocarbon wash oil to effect high purities. In general, the following processes are involved: Feed preparation, concentration of aromatics by sulfur-dioxide extraction, separation of sulfur dioxide and wash oil from non-aromatics, separation of the sulfur dioxide from the aromatics, fractionation of the aromatic stream, and sulfur-dioxide recovery. Details of these are described in the following paragraphs. A flow diagram of the process is presented in Fig. 1.

*Continental Oil Company, Lake Charles, Louisiana.

**Continental Oil Company, Houston, Texas.

†Presented before the American Petroleum Institute's Division of Refining, Houston, Texas, May 12, 1954.

Feed Preparation

The charge to the unit is a depentanized, light catalytic reformate produced by a UOP‡ Platformer. The charge to the Platformer is a carefully controlled, narrow-boiling naphtha fraction which has the properties shown in Table 1. This naphtha contains practically all of the C_6 and C_7 aromatics and naphthenes contained in the straight-run gasoline produced from the crude oil processed in the refinery. Naphthenes and aromatics in the C_8-molecular-weight range also are included in the charge to utilize the capacity of the unit.

The charge naphtha is prepared as a heart-cut product on two 50-tray fractionating towers. The light reformate produced from this heart-cut naphtha has the physical properties shown in Table 2. The reformate in inhibited with 1 lb to 2 lb per 1000 bbl of Koppers DBPC (2-6 ditertiary butylparacresol) inhibitor as it leaves the Platformer to prevent the formation of resin contaminants in storage or under

‡Universal Oil Products Company.

FIG. 1. Flow diagram of an SO_2 benzine-toluene extraction unit.

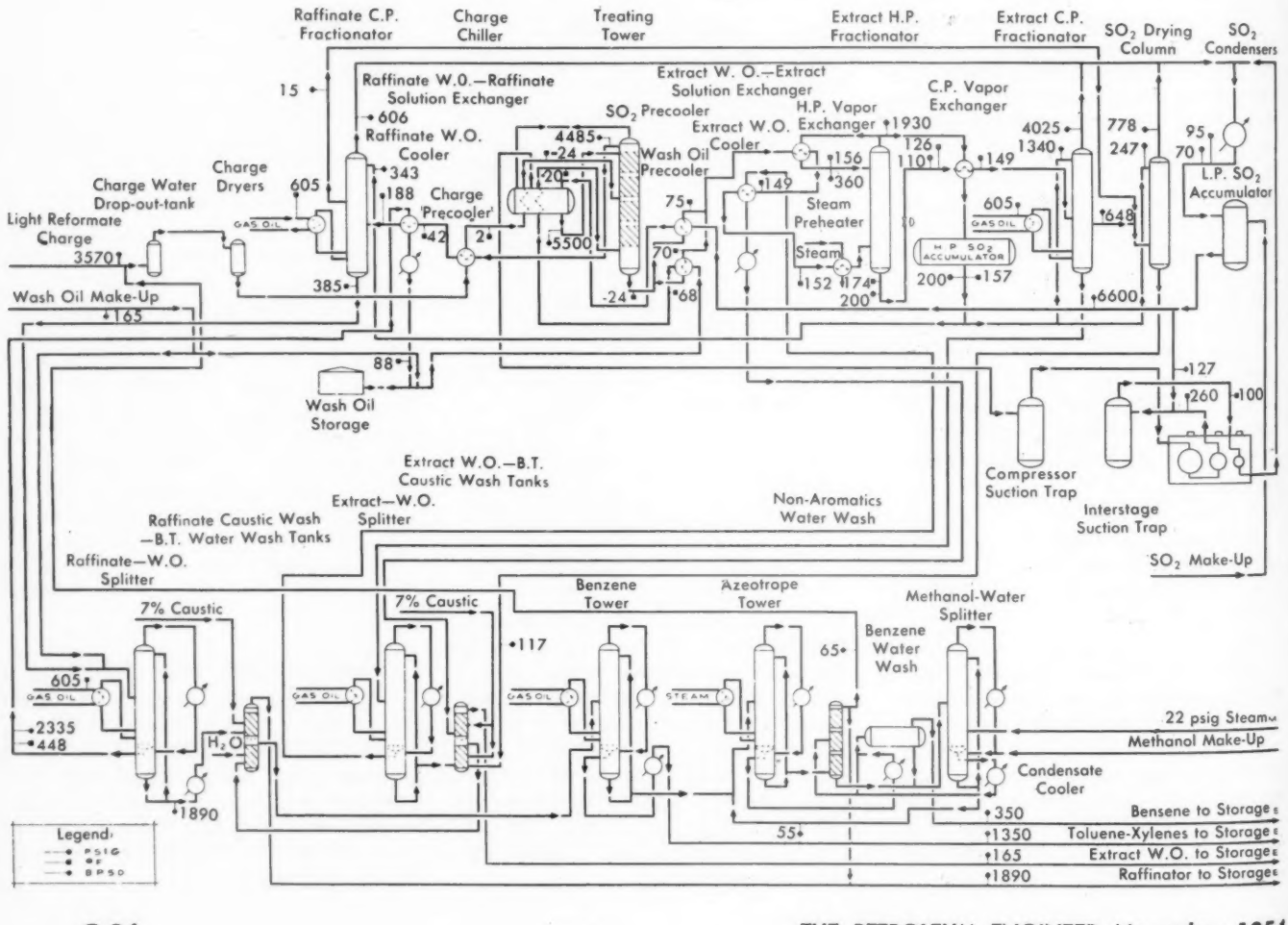

TABLE 1. Typical properties of heart-cut naphtha.

ASTM distillation, fahrenheit:	
Initial boiling point	180
5-per cent point	186
10-per cent point	187
30-per cent point	191
50-per cent point	195
70-per cent point	201
90-per cent point	210
95-per cent point	215
Dry point	220
PONA* analysis:	
Liquid, per cent by volume:	
C_5 naphthenes	0.1
C_6 naphthenes	12.9
Benzene	1.9
C_7-and-heavier naphthenes	31.4
Toluene	5.8
Xylenes	1.2
Paraffins	46.7
Sulfur, per cent by weight	0.033
ASTM octane number (D 908, research method):	
Without TEL addition	65.6
With addition of 3 ml TEL per gal	84.2

* Paraffins, olefins, naphthenes, and aromatics.

the low temperatures which exist in the treating section. The intermediate storage tanks between the Platformer and the extraction unit are equipped with floating roofs to minimize resin formation resulting from reactions with oxygen.

Aromatics Concentration

The light reformate enters the sulfur-dioxide extraction unit at a designed rate of 3570 bbl per stream day through a water dropout tank which is equipped with an audible alarm. The alarm is provided to signal the operator in the event that free water, which could cause serious corrosion problems, enters from storage. The reformate then passes through alumina driers for maximum removal of moisture, is chilled to approximately 5 F in the precooler, and then is passed through the charge chiller in which the temperature is dropped to —25 F.

TABLE 2. Typical properties of light catalytic reformate.

ASTM distillation, fahrenheit:	
Initial boiling point	154
5-per cent point	174
10-per cent point	179
20-per cent point	185
30-per cent point	189
40-per cent point	194
50-per cent point	198
60-per cent point	203
70-per cent point	209
80-per cent point	217
90-per cent point	227
95-per cent point	243
Dry point	260
End point	286
Recovery, per cent	99
Gravity, deg API	53.5
Reid vapor pressure, lb	3.7
Color, NPA	30
ASTM gum, mg per 100 ml	Nil
ASTM octane number (D 908, research method):	
Without TEL addition	82.0
With addition of 3 ml TEL per gal	94.0
PONA analysis:	
Liquid, per cent by volume:	
Paraffins	47.4
Olefins	1.1
Naphthenes	5.0
Aromatics	46.5
Benzene	10.7
Toluene	31.3
C_9 aromatics	4.5

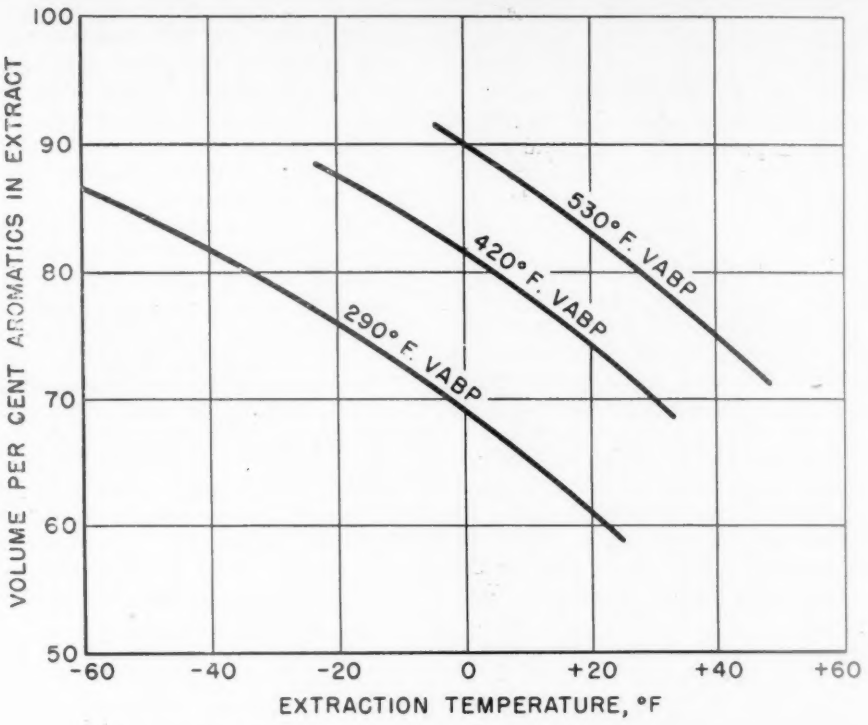

FIG. 2. Effect of extraction temperature on aromatic concentration in extract.

The cold naphtha is charged to the treating tower which contains four separate raschig-ring-packed sections. The naphtha flow normally enters the tower between the two middle sections; however, some flexibility of operation can be achieved by introduction of the charge between the two top sections or the two bottom sections. The relatively light naphtha tends to flow upward through the tower countercurrent to the heavier sulfur dioxide. The aromatics in the charge are dissolved selectively in the sulfur-dioxide phase, and are carried to the base of the tower. The raffinate phase, which contains a small amount of the sulfur dioxide, overflows from the top of the tower. This tower operates at 5.5 psia through a pressure-equalizing line with the charge chiller and, thus, the low treating temperature of —20 to —24 F is maintained.

Fig. 2 illustrates the effect of extraction temperature on the concentration of aromatics in the extract solution for charge stocks of different volumetric average boiling points.[1] These data illustrate that, for a normal sulfur-dioxide-to-naphtha charge ratio and a treating temperature of —20 F, the hydrocarbon portion of the extract-solution stream would contain approximately 75 per cent aromatics. In the conventional sulfur-dioxide extraction process this stream would pass to the distillation section for processing; however, in the modified extraction process as employed by Continental Oil Company a relatively heavy paraffinic hydrocarbon is introduced into the treating tower below the bottom-packed section for the purpose of displacing the light paraffinic and naphthenic components of the charge naphtha from the extract solution. This wash oil is of sufficiently high boiling point (kerosine range) so that it can be separated from the extracted aromatics component by simple distillation.

The sulfur dioxide flows, on level control, under its own pressure from a low-pressure accumulator to the shell side of the charge chiller. This chiller is maintained at 5.5 psia by automatic pressure control operated through the hydraulic governor on the gas engines which drive the sulfur-dioxide compressors. A pump charges the liquid sulfur dioxide, on flow control, from the chiller to the treating tower. The design circulation rate is 5500 bbl per stream day. Typical properties of the sulfur dioxide are summarized in Table 3.[2, 3]

TABLE 3. Properties of sulfur dioxide.

Molecular weight	64.06
Melting point, deg F	—103.9
Boiling point, deg F	14
Density of liquid at 80 F, lb per cu ft	85.03
Specific gravity at 80 F	1.363
Density of gas at 0 deg C and 1 atm, lb per cu ft	0.1827
Critical temperature, deg F	314.82
Critical pressure, psia	1,141.5
Heat of vaporization, Btu per lb:	
0 F	170.3
50 F	160.0
100 F	148.2

The wash oil is charged to the bottom of the treating tower at a designed rate of 2500 bbl per stream day after it first has passed through the wash-oil precooler in which the temperature is lowered to 68 F, and then through a tube bundle in the sulfur-dioxide chiller in which the temperature is dropped to

—20 F. The wash oil is not dried before it is brought into the system, and it sometimes contains enough moisture to cause ice formation in the tubes of the wash-oil precooler. For this reason a line is provided so that liquid sulfur dioxide form the low-pressure accumulator can be injected for de-icing purposes.

Raffinate Recovery

The raffinate solution—which consists of approximately 275 bbl of sulfur dioxide, 1875 bbl of raffinate, and 2335 bbl of wash oil—overflows from the top of the treating tower, on level control, and exchanges heat in the charge precooler in which its temperature is raised to 42 F. After heat exchange with hot wash oil, whereby its temperature is increased to 188 F, the raffinate is charged to the raffinate CP (condenser-pressure) fractionator. This tower has 20 bubble trays, and was designed to operate at the sulfur-dioxide-system condenser pressure. All of the sulfur dioxide is removed from the raffinate solution in this one tower, so close temperature control is necessary to prevent contamination of both the overhead and the bottom streams. It has been found that best operating control can be achieved by operating the tower with a pressure-control valve on the overhead stream.

The raffinate solution flows from the base of the fractionator, on level control, to the raffinate—wash-oil splitter. The raffinate is taken overhead, subcooled, caustic-washed, and sent to storage. The properties of this raffinate —which is a promising source of *iso*hexane, *iso*heptane, and paraffin solvents—are shown in Table 4. The wash oil is circulated from the base of the splitter tower through the wash-oil-raffinate solution exchanger in which the temperature is lowered from 448 F to 218 F. The temperature is then further lowered to 88 F in the raffinate-wash-oil cooler, and is returned to the suction of the wash-oil charge pump or to the wash-oil storage tank which floats on the line.

TABLE 4. Properties of Raffinate.

ASTM distillation, fahrenheit:	
Initial boiling point	160
10-per cent point	166
50-per cent point	178
90-per cent point	202
95-per cent point	213
Dry point	220
Gravity, deg API	73.3
Aromatics, per cent by volume	0.5
Olefins, per cent by volume	2.0
Paraffins and naphthenes, per cent by volume	97.5

Extract Recovery

The extract solution is pumped from the base of the treating tower on interface level control, and the flow is split for parallel heat exchange in the sulfur-dioxide precooler and the wash-oil precooler. The streams—at temperatures of 75 F and 70 F, respectively—are combined, and they exchange heat with the reflux of the extract HP (high-pressure) fractionator which raises the temperature to 149 F. The temperature is raised to 152 F in a stream preheater, after which the extract is charged to the tract HP fractionator.

Sulfur dioxide is recovered from the extract solution in two stages—as opposed to the one stage in the raffinate system—in order to effect heat recovery from condensing sulfur dioxide and to provide liquid sulfur-dioxide reflux This is accomplished by operation of the first stage at 200 psig, which provides condensing vapors at elevated temperatures for heat recovery and permits an expansion cooling of the bottoms stream for condensing reflux. The reflux for the HP fractionator is furnished by controlled heat exchange with the cold-extract feed, as described in the preceding paragraph.

Approximately 20 per cent of the sulfur dioxide charged to this tower is taken overhead and condensed at high pressure by exchange with the tower bottoms which have been cooled from 174 F to 126 F by taking a pressure drop of 90 psi across a control valve. The condensed sulfur dioxide is used to reflux the raffinate and extract CP towers and the sulfur dioxide drying column and, because it is at 200 psi, no pumps are needed for circulation.

The cooled HP-fractionator bottoms —extract solution which contains approximately 80 per cent of the sulfur dioxide—are charged to the extract CP tower, which is operated in a manner analogous to the raffinate CP tower. The sulfur dioxide is taken overhead to the low-pressure accumulator from which it is recirculated to the treating tower. The extract solution flows from the base of this tower, on level control, to the extract-wash-oil splitter.

This splitter is operated in a conventional manner to separate the concentrated aromatics from the wash oil. The aromatics are taken overhead, are washed with caustic to remove the last traces of sulfur dioxide, and are sent to the benzene tower. The wash oil is pumped from the base of the splitter, and is returned to the refinery after heat exchange with the extract solution and treatment with caustic.

This portion of the wash oil is removed from the system because it would include any heavy aromatics entering in the charge stock and all aromatic components included in the original wash oil. Either of these heavy aromatics would make the wash oil less desirable for contacting the extract solution in the bottom section of the treating tower. It also has been found by experience that the bulk of the resins formed in the system tend to concentrate in this stream. Makeup wash oil is brought into the system by taking a slip stream from the kerosine stripper on the crude topping unit and injecting it, on flow control, into the raffinate-wash-oil splitter in which any light ends and moisture are removed.

Sulfur-Dioxide Recovery

The sulfur dioxide vaporized in the charge chiller is compressed in three stages to condenser pressure, and is the only vapor required to be handled by compressors. This vapor, the vapors from the two CP fractionators, and the drying-tower overhead are condensed in common sulfur-dioxide condensers, and the liquid is returned to the low-pressure sulfur-dioxide accumulator.

A comparison of the temperature-pressure relationship on this accumulator with the temperature-pressure data for pure sulfur dioxide gives the opertor an indication of the extent of contamination with fixed gases. The fixed gases are removed from the system by bleeding a small vapor stream from the lower half of the shell of each condenser through a tube bundle located in the charge chiller into the de-aerating condenser-condensate receiver. A back-pressure valve, manually adjusted from the control panel, bleeds the fixed gases to the atmosphere. This liquid sulfur dioxide is released from the base of the receiver, on level control, into the charge chiller.

The sulfur dioxide is kept dry by removal of moisture in a drying tower from slip streams taken from the vapor space above the tenth tray in the CP fractionators. Approximately 632 bbl per stream day are taken from the extract CP tower, and 10 bbl per stream day are removed from the raffinate CP tower. The bottoms from the drying tower—which contain approximately 22 bbl per stream day of aromatics, 3 bbl per stream day of raffinate, and 1032 lb per day of sulfur dioxide—currently are being washed with caustic and water and then injected into the aromatic-concentrate stream as it enters the distillation section.

An additional drying tower, which will operate at an interstage pressure of 10 psig, is being fabricated for installation to recover the 1032 lb of sulfur dioxide. The hydrocarbons from the base of this tower will be processed as described hereinbefore; however, should additional purity be required, the stream can be returned to the naphtha-charge driers for reprocessing.

Benzene Recovery

The aromatic concentrate from the extract-wash-oil splitter is charged to the benzene tower in which an impure benzene is produced as the overhead

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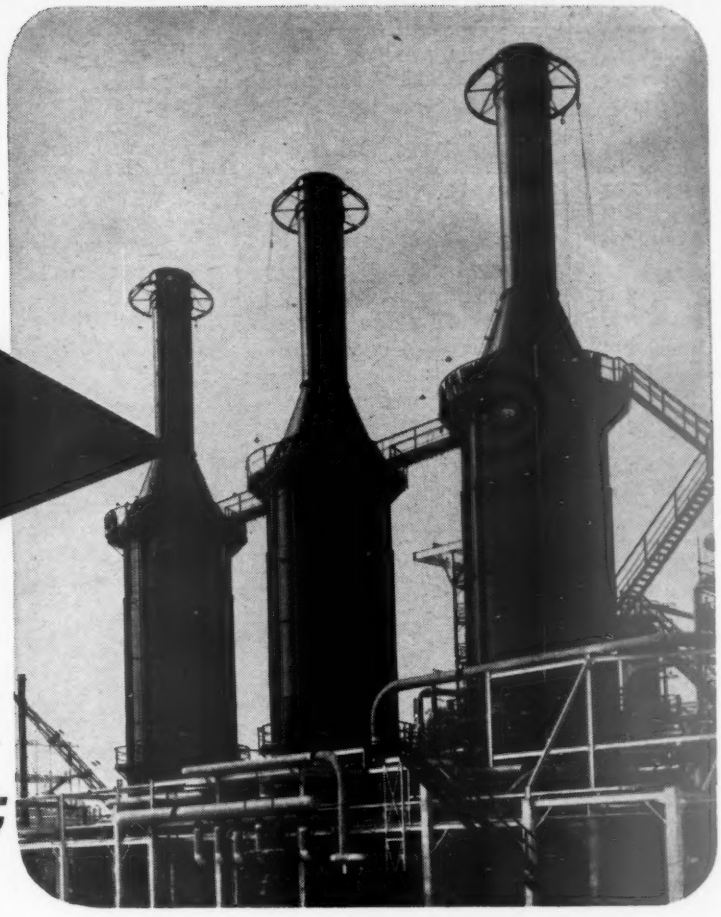

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product. The bottoms product is a toluene-xylene fraction which has the physical properties summarized in Table 5, and it is sent directly to storage.

The end use of the benzene produced at this plant is in Continental Oil Company's synthetic-detergent alkylate. For this purpose it is essential that the purity of the benzene be greater than 98.5 per cent, which requires that the content of paraffins, olefins, and naphthenes in the benzene boiling range be reduced by some means such as azeotropic distillation. Continental selected methanol for this purpose because it is easy to handle, inexpensive, does not involve royalty payments, and can be recovered easily from contaminating hydrocarbons. Some selected data on methanol azeotropes are summarized in Table 6,[4] and a material balance is shown in Table 7.

TABLE 5. Properties of toluene-xylenes streams.

Existent gum, mg per 100 ml	0.8
Gravity, deg API	31.4 to 31.8*
ASTM distillation, fahrenheit:	
Initial boiling point	215 to 217*
10-per cent point	226 to 231*
50-per cent point	231 to 334*
90-per cent point	240 to 250*
End point	290 to 308*
Sulfur, per cent by weight	0.006
Doctor test	Sweet
PONA analysis:	
Liquids, per cent by volume:	
Benzene	2.3
Toluene-xylenes	95.8
Paraffins-naphthenes	0.9
Olefins	1.3
Blending value ASTM (D 908) research method with addition of 2.0 ml TEL per gal	118.5
Blending performance number ASTM (D 614) aviation method with addition of 4.6 ml TEL per gal	103
Blending performance number ASTM (D 909) supercharge method with addition of 4.6 ml TEL per gal	250

* Typical inspection range.

Benzene and methanol are charged to the azeotrope tower. Benzene is produced as the bottoms product and is water-washed before it goes to storage. Typical properties of the benzene produced on this unit are summarzied in Table 8. It will be noted from these data that the benzene produced does not meet the acid wash colors of 2 and 1 for industrial-grade and nitration-grade benzene, respectively. If it were desired to market benzene of these grades, it would be necessary to acid-treat or clay-treat the material to meet the required color specifications.

The methanol is water-washed in a three-stage tower, whereby the contaminating hydrocarbons are separated and discarded to gasoline storage. The water is removed from the methanol in a splitter, and both components are recycled.

Costs

The overall plant material balance is shown in Table 9, and is the basis for the operating costs shown in Table 10. Because of insufficient cost history at this time the direct operating cost of 25.8 cents per barrel of charge should be used with reasonable caution. The utility and labor expenses are based on actual plant observations, but they represent only to-thirds of the operating cost. The relatively high fuel cost can be attributed to the fact that most of the reboil heat is supplied to the unit through a gas-oil heating belt. This would appear in the stream costs of more conventional units. Maintenance and chemical costs have been based on design figures because there are indications that they are realistic.

TABLE 6. Methanol-hydrocarbon azeotropes.

	Methanol-hydrocarbon azeotrope			Benzene azeotrope	
Component:	Boiling point (deg F)	Boiling point (deg F)	Methanol-hydrocarbon (mole per cent)	Boiling point (deg F)	Benzene (mole per cent)
nParaffins:					
nPentane	97.1	87.4	13.0	....	....
nHexane	156.1	123.1	51.0	156	5.5
NHeptane	209.1	138.4	76.8	176	99.5
Isoparaffins:					
Isobutane	82.2	76.1	9.0	....	....
2, 3-dimethylbutane	136.6	113.0	36.0	....	....
2, 2, 4-trimethylpentane	210.6	138.9	80.0	176	98.5
Olefins:					
3-methylbutene-1	72.5	67.6	6.3	....	....
2-methylbutene-2	100.0	89.2	13.6	....	....
Cyclohexene	181.9	132.6	63.0	....	....
Naphthenes:					
Cyclopentane	120.7	101.8	26.3	....	....
Methylcyclopentane	161.3	124.3	55.3	161.2	10.7
Cyclohexane	177.3	129.6	61.0	171.5	56.8
Aromatics:					
Benzene	176.2	137.1	61.4	....	....
Toluene	231.1	146.8	86.5	....	....
Methanol	148.1	....	....	137.1	38.6

TABLE 7. Material balance around azeotrope tower.

	Composition (per cent by volume)		
	Feed stream	Azeotrope-tower overhead	Azeotrope-tower bottoms
Methanol	9.1	36.0	....
Benzene	86.3	48.6	99.0
Toluene	....	....	....
Paraffins-naphthenes	2.4	8.7	0.3
Olefins	2.2	6.7	0.7
Stream, bbl per stream day	402	102	300

TABLE 8. Properties of benzene stream.

ASTM distillation, fahrenheit:	
Initial boiling point	175
2-per cent point	176
5-per cent point	176
10-per cent point	176
50-per cent point	177
90-per cent point	177
95-per cent point	177
Dry point	177
PONA analysis:	
Liquid, per cent by volume:	
Benzene	99.0
Toluene	....
Paraffins-naphthenes	0.3
Olefins	0.7
Freeze point, deg C	4.95
Gravity, deg API	28.9
Acid-wash color, NPA	5

Extraction Unit

Fig. 3 shows a pictorial view of the aromatics extraction unit, with the treating tower in the center foreground. The extraction section is laid out in line to the left and right of this treating tower. The compressor building in the left foreground houses the com-

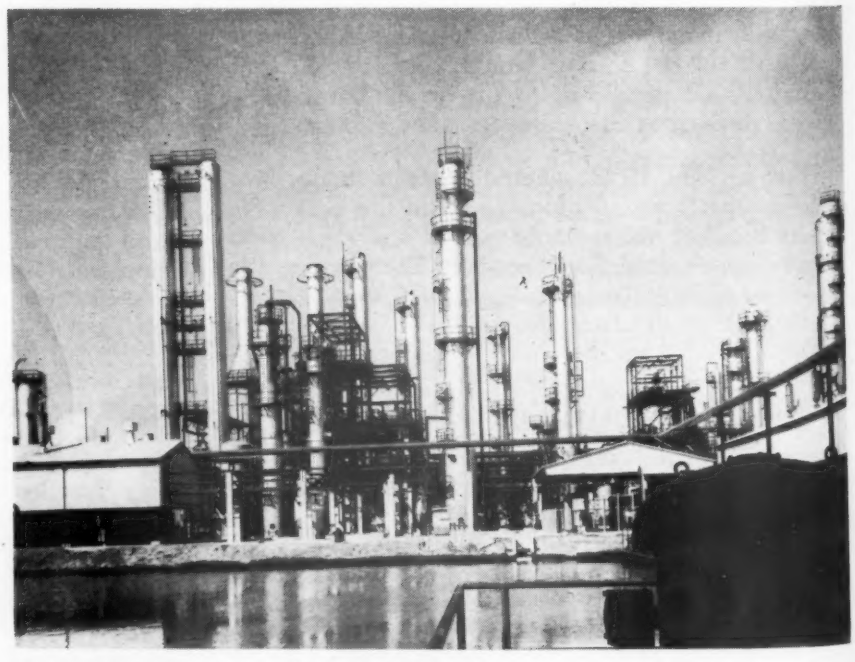

FIG. 3. Extraction section of Continental's unit.

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TABLE 9. Material balance and recoveries for sulfur-dioxide extraction unit.

	Composition (per cent by volume)					
	Feed stream	Raffinate	Benzene	Toluene-xylenes	Azeotrope-tower overhead	Recovery
Benzene	10.7	0.3	99.0	2.3	76.0	98.4
Toluene-xylene	35.8	0.2	....	95.8	....	99.7
Paraffins-naphthenes	51.7	97.5	0.3	0.9	13.5	....
Olefins	1.8	2.0	0.7	1.3	10.5	....
Stream, bbl per stream day	3570	1875	300	1330	65	....

TABLE 10. Investment and operating cost of modified sulfur-dioxide plant.

Plant design:	
Charge capacity, bbl per stream day	3570
Basis charge:	
Sulfur dioxide, per cent by volume	154
Wash oil, per cent by volume	70
Temperature, deg F	—21
Plant cost, dollars	2,660,000
	Cents per barrel of charge
Direct operating costs:	
Utilities:	
Fuel at 11.2 cents per million Btu	6.8
Cooling water at 0.86 cent per 1,000 gal	1.1
Power at 1 cent per kwh	1.6
Steam at 25 cents per 1,000 lb	1.5
Subtotal	11.0
Sulfur-dioxide solvent at 6.35 cents per lb	1.7
Chemicals	1.5
Labor	6.4
Maintenance	5.2
Royalty	None
Total	25.8

pressors for the extraction unit and the platformer. The two 50-tray fractionators used in the preparation of the heart-cut naphtha are shown in the left background of the picture. Fig. 4 is an elevated view which shows the distillation-section towers in the foreground. The sulfur-dioxide condensers and charge chillers are located in the structure in the center of the photograph.

Conclusion

The sulfur-dioxide extraction process, modified for utilization of a hydrocarbon wash oil, provides an economical means for the extraction of benzene and toluene simultaneously from a catalytic reformate. Recoveries upward of 98 per cent have been demonstrated in a new plant with the use of one extraction tower.

Single-stage separation of sulfur dioxide from the raffinate can be achieved at operating pressures of 75 psig.

A simple methanol azeotropic distillation is all that is required to improve to 99 per cent the purity of benzene produced in the modified extraction unit.

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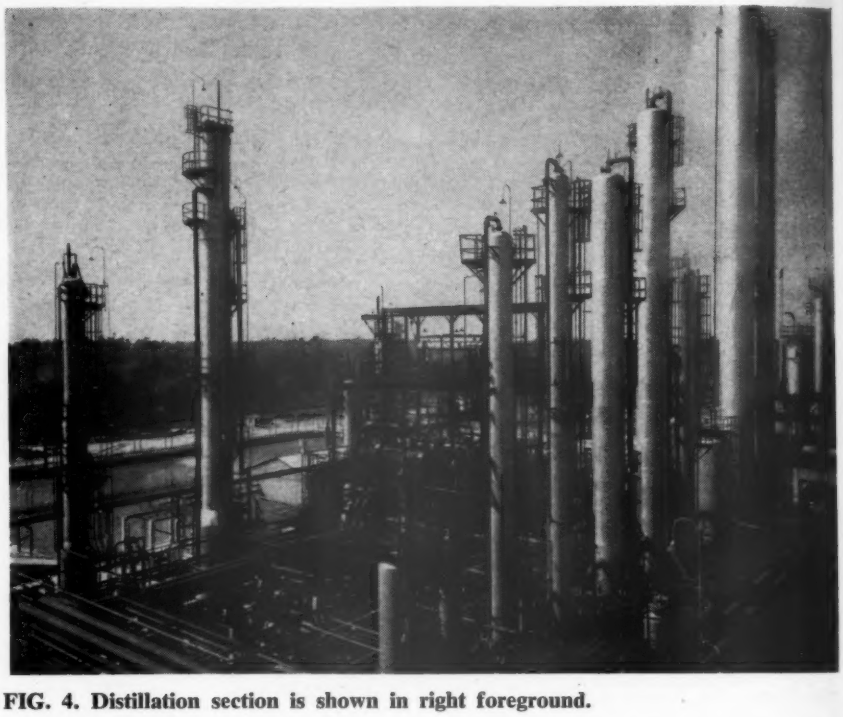

FIG. 4. Distillation section is shown in right foreground.

Manufacture and Distribution of Ethylene‡

Ethylene by cracking ethane of propane is purified, and separated from methanes, ethane by fractionation

P. W. CORNELL,* W. H. LITCHFIELD,† and H. M. VAUGHAN†

BECAUSE the operation of an ethylene plant starts with its raw-material source, and because, in the case of an oil company, this raw material may be either refinery gas or propane, the problem of continuity of raw-material supply becomes a fundamental operating consideration. If propane is to be used as a feedstock, conventional storage of a number of types can be provided, and at a cost which is not prohibitive.

If refinery gases—with their contained ethane, ethylene, and perhaps propane—are to represent the feed source, storage is not economically feasible, inasmuch as so much methane and hydrogen are contained in the cracked gases, When refinery gas is processed, the feed supply must be controlled by spilling; i.e., the ethylene plant will take as much gas supply as it needs, and will spill the remainder back to the refinery fuel sytem. This may mean a substantial amount of excess compression, because the gas streams which are to be mixed must be sufficient to insure a relatively uniform composition to the ethylene unit. Even with such a spillback arrangement stable ethylene unit feed can only be obtained in a large refinery which has numerous gas-producing units.

Of equal importance is the effect which the ethylene-unit off-gases have on the refinery fuel-gas system. Not only does the ethylene plant return the lower Btu components of the feed gas to the refinery; but, in addition, when the by-product gas from ethylene manufacture itself, which consists

*Gulf Oil Corporation, Pittsburgh, Pennsylvania.

†Port Arthur refinery, Gulf Oil Corporation, Port Arthur, Texas.

‡Presented before the American Petroleum Institute's Division of Refining, Houston, Texas, May 12, 1954.

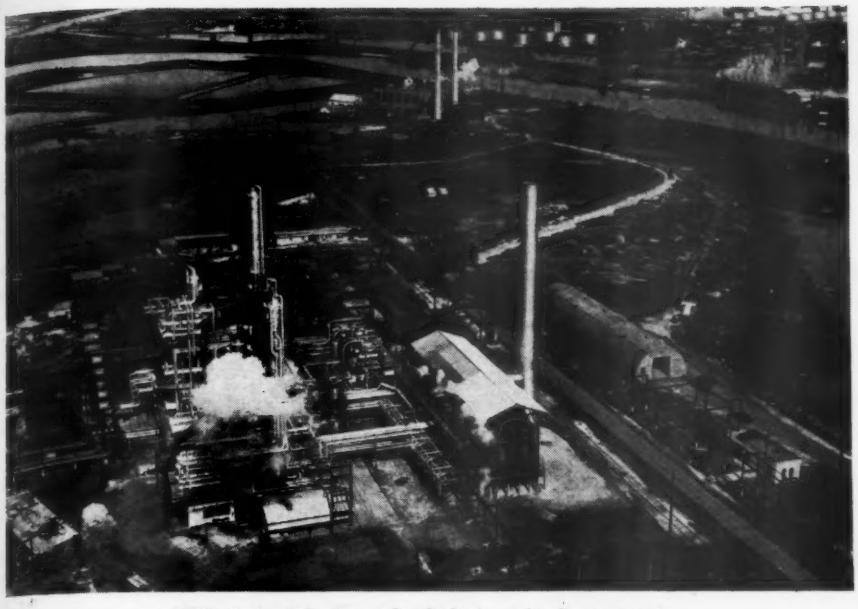

FIG. 1. Aerial view of ethylene unit, foreground.

largely of methane and hydrogen, is added to the refinery fuel gas, the net result is that the Btu per cubic foot of the refinery gas stream is materially diminished. This need not be serious if proper provision is made for the accommodation of the changed nature of the fuel gas.

Successful operation of the ethylene unit must include the installation of the instruments and equipment, as well as the establishment of operating procedures, necessary to maintain reasonably uniform refinery operation in spite of any upsets to the refinery's fuel system caused by changes in the operation of the ethylene unit. The installations may include equipment for flaring large volumes of gas during short periods of upset, or in case of failure of the ethylene plant equipment. In addition, the ethylene-unit feed systems must provide a feed-gas spill of sufficient volume to assure minimum upset of the ethylene unit when refinery units go off and on, or when the operating rate of the ethylene unit needs to be changed.

Ethylene Storage

It is apparent that a stable ethylene supply is dependent upon more than a stable raw-material source. Storage must be provided for the ethylene itself. Gulf Oil Corporation's distribution system involves more than 130 miles of pipe line, and the fluctuations in pressure which such a line can tolerate can provide a substantial amount of ethylene storage.

Although the storage capacity of the pipe line serves to smooth out variations in producing-plant operations, Gulf has found that the needs of its customers, as well as the type of manufacturing operations involved, require a substantial additional amount of storage. Any type of ethylene storage is exceedingly expensive; therefore, it is improbable that 30 to 60 days' storage will ever be attained, as is customary for most of the products of the oil industry. Nevertheless, a stable source of ethylene requires a substantial investment in ethylene storage.

The problems associated with ethylene storage are somewhat similar to those of the more familiar propane storage. In general, propane storage is costly because of the high pressure required at atmospheric temperature, or because refrigeration is necessary if the storage is to be at low pressure.

The problems in ethylene storage are the same, only more so. The temperatures must be lower, and the pressures must be higher. Moreover, the lower density of the stored material requires a substantially larger storage volume for the retention of the same weight of stored material.

As a matter of fact, the entire philosophy of the operation of an ethylene plant can be summed up in these three words: "Only more so."

Ethylene Manufacture

Before the specific details of the process operation are described, the philosophy of ethylene manufacture can be illustrated through a consideration of its power requirements. For easy illustration we have compared, in Table 1, the manufacture of ethylene with a few common refinery operations, on a basis of the power-input requirements of each of the processes. We could have used energy input on the basis of fuel and steam consumption, but the use of rotating and reciprocating machinery also serves to illustrate the higher demand for maintenance and service. A comparison of the units of salable product per unit of mechanical-energy input for three typical types of refinery units and an ethylene plant is given in Table 1.

TABLE 1. Units of salable product per unit of mechanical-energy.

Type of plant	Input
Ethylene unit	1
Fluid catalytic cracking unit	40
Lubricating-oil solvent-treating unit	200
Crude-oil topping and vacuum unit	700

Although there will be differences in the requirements of specific designs of ethylene plants, catalytic cracking units, topping units, or lubricating-oil solvent plants, differences between units of the same type cannot be great enough to destroy the relatively positions in the comparison.

For a large-scale chemical intermediate ethylene has a high energy requirement per unit of product, and its manufacture involves the typical problems that one would anticipate from such a concentration of mechanical equipment.

Ethylene Unit Sections

Apart from equipment for feedstock preparation and product distribution, an ethylene unit consits of three fundamental parts, as shown in Fig. 1. First of these parts is the ethylene-formation section; second is the purification section, with the equipment necessary for the auxiliary purification operations and the third is the ethylene-separation section.

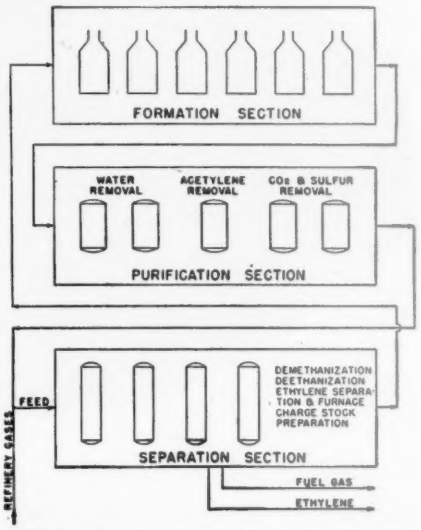

FIG. 2. Three main sections of the ethylene unit.

Ethylene Formation

Several types of ethylene-formation processes are available. By far most common is that which employs some sort of externally-fired tubular coil by means of which the feedstock is thermally cracked so as to provide ethylene in a mixture of hydrogen and other hydrocarbons. A number of other processes can be employed for formation of ethylene, but the only other ethylene source used by Gulf is by-product ethyl-

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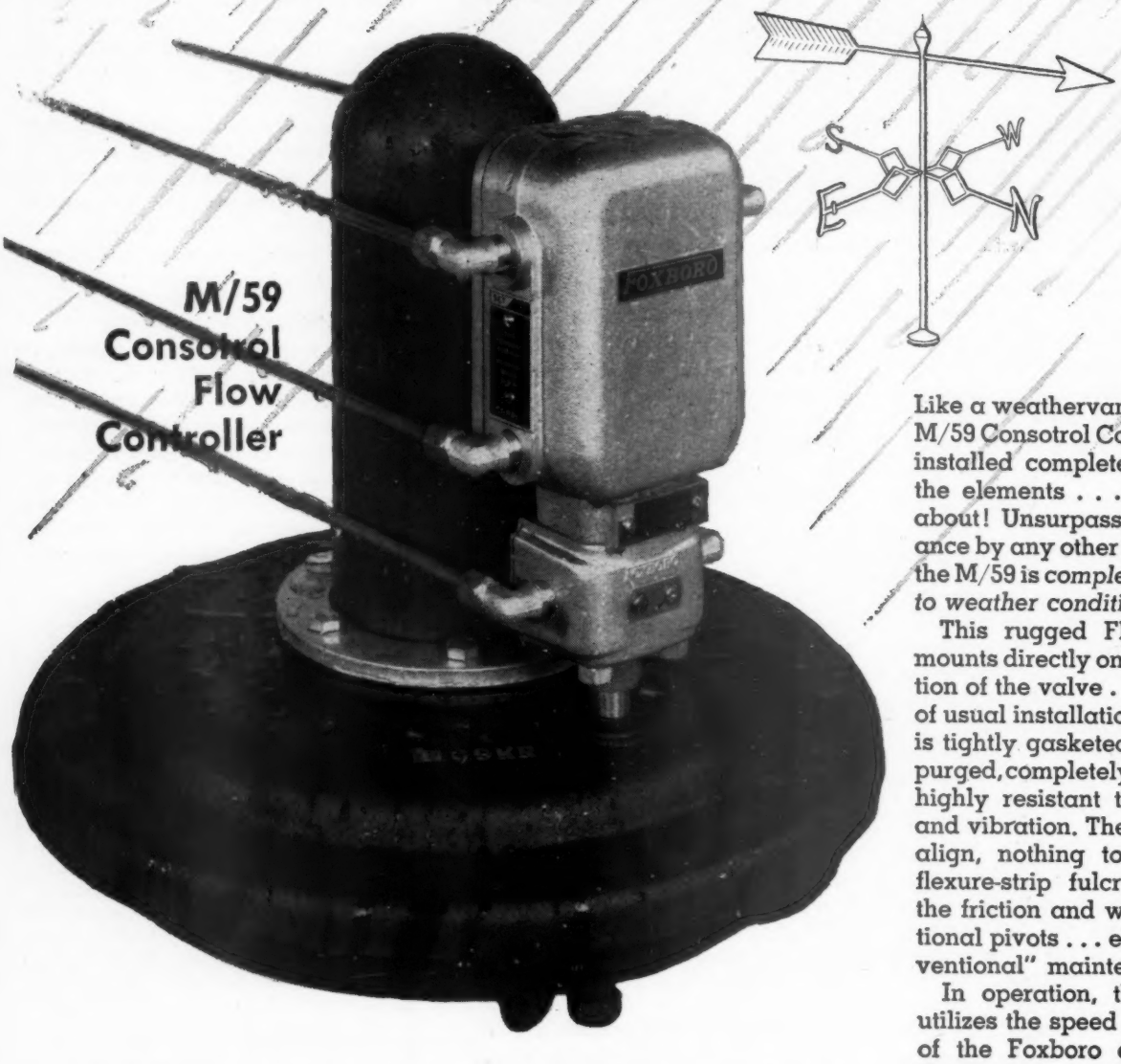

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ene contained in the refinery gases made in those cracking operations, either thermal or catalytic, designed to produce gasoline and other such oil products.

For the sake of the record, however, some of the other methods for the formation of ethylene should be mentioned. One which has been wisely used in the past involves the dehydration of ethyl alcohol, much of which may have been produced originally from ethylene rather than from agricultural sources. This situation may seem strange at first; but it has been found expedient to go to the trouble of converting ethylene to ethanol, only to dehydrate that same ethanol later in order to produce ethylene for other purposes.

Ethylene is a difficult material to transport for any considerable distance because of its low critical point and light weight. Under certain circumstances, it can be profitable to provide a crude-ethylene stream in an area where the ethylene is of little value, to convert that ethylene to ethanol, to transport the ethanol to a location where ethylene is needed but would not be available otherwise, and then to dehydrate in order to provide the required ethylene.

Numerous other methods for the formation of ethylene have been used or proposed. The most widely known of these cracking processes employ pebble heaters, refractory checker heaters, and partial-oxidation reactors.

Purification Equipment

The second part of an ethylene-producing unit contains the auxiliary purification equipment. Purification would include, to the extent necessary: Removal of sulfur, usually in the form of hydrogen sulfide or carbonyl sulfide; removal of water, removal of acetylene and removal of carbon dioxide Sulfur compounds and carbon dioxide can be removed by means of conventional processes such as amine and caustic solutions in series. These scrubbing towers, however, although conventional in type, must be operated for far more complete removal than is usually required.

Sulfur compounds and carbon dioxide are undesirable for some of the uses for which ethylene is consumed; therefore, considerable attention must be given to insure that they are removed to the low parts-per-million level. Acetylene can be lowered to the desired level by two general procedures: One by hydrogenation, and the other by solvent extraction with one of the several solvents available for that purpose. Gulf employs the former method, and passes the cracking-heater effluent, which is rich in hydrogen, over a selective hydrogenation catalyst

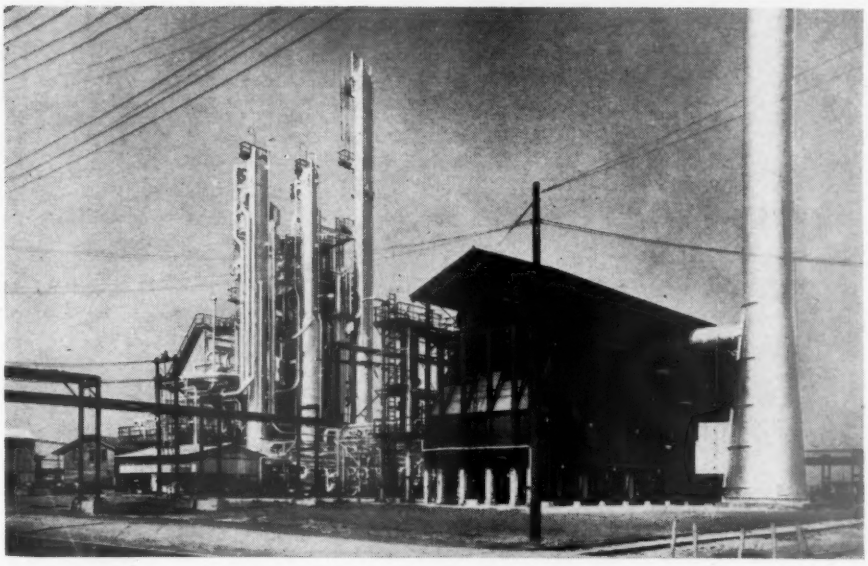

FIG. 3. Ethylene unit, with production section at right, and separation section, left.

under closely controlled conditions.

The most critical of all the auxiliary purification steps, however, is the removal of water. The feed to an ethylene-unit separation section must be dehydrated to a very low dew point. With the very low temperatures of the ethane-ethylene fractionator, or the dementhanizer, virtually all water must be removed in order to prevent the formation of hydrates in the column. The removal of water, even to low dew points, is a well-known and well-understood operation, but its importance is such that too much drying capacity in an ethylene unit is highly unlikely. Moreover, one cannot be too careful in the operation of whatever drying equipment is available.

Some efficient form of solid desiccant generally is employed in order to achieve the required dew point. Because this is, of necessity, a cyclic operation, anything which can be done to diminish the load on the solid desiccant driers will simplify the operation of the plant. The first and obvious thing to do is to chill the feed for the purpose of eliminating the water at the closest practical approach to the point at which hydrates or ice would otherwise be formed.

A fairly recent development is the di- or triethyleneglycol dehydration unit which is widely used in the natural-gas industry. Gulf now has such a unit in operation on an ethylene unit, as a partial dehydrator which precedes the solid desiccant driers. This unit consists of an absorber in which the gas stream which is to be dried is continuously contacted with triethylene glycol. The glycol absorbs sufficient water to lower the dew point of the gas 35 to 40 F. The rich glycol is charged to a stripper column from which the water is removed overhead, and the stripped glycol is returned to the absorber. Inasmuch as this is a continuous system, its operation is relatively simple. By this means the water load on the solid desiccant driers is reduced more than 50 per cent.

One very effective method for water removal employed in some ethylene units (but not in those which Gulf Oil Corporation operates) involves the same type of freezing-out procedure sometimes used for water and carbon-dioxide removal in the feed-preparation section of liquid-oxygen plants.

Ethylene Separation

The third principal portion of a unit for the production of commercial ethylene is the section comprising the equipment necessary for the separation of the ethylene produced and purified by any of the methods described herein. One of the earliest of the separation methods practiced was chemical conversion to a final product. This has been done, to a large extent, in the formation of ethyl alcohol via the familiar sulfuric-acid extraction process.

Except for this or other-chemical extraction processes, all ethylene separation systems employ three principal steps. These are the elimination of methane-and-lighter, the elimination of propylene-and-heavier, and the final splitting between ethane and ethylene.

A widely used method for elimination of methane-and-lighter from the gas charge to the separation system is that which involves reboiled absorption. This, incidentally, is the principle employed in the separation system of Gulf Oil Corporation's first ethylene unit. The process involves the passing of feedstock through a refrigerated column which employs an absorption oil and added reboiling. The bottom of this absorption column is provided with

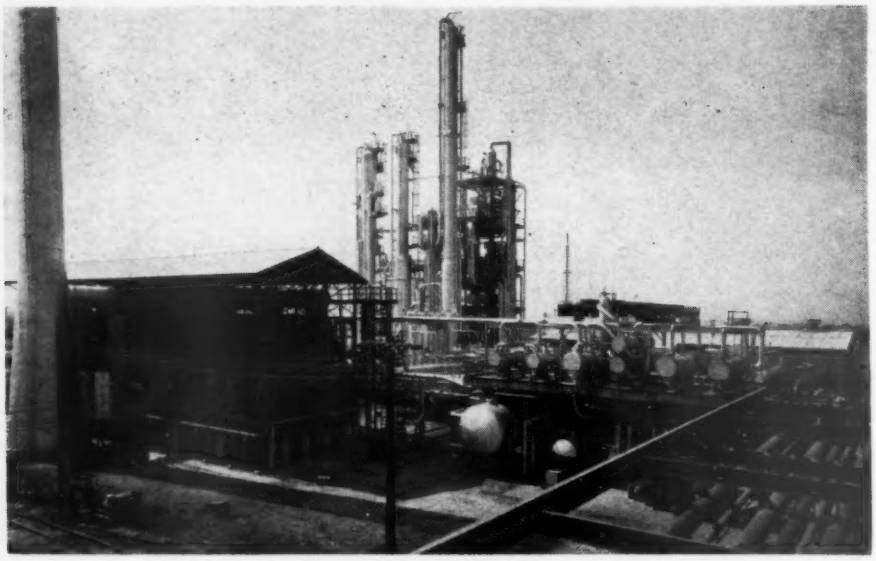

FIG. 4. Another view of ethylene unit, with formation section at right foreground, separation section in center, rear; and compressor section right background.

a stripping section which aids in the rejection of the methane and lighter constituents overhead. The fat absorption oil, with its content of ethylene-and-heavier, is then passed to succeeding fractionating columns for the separation of lean oil, ethylene, and the cracking-furnace recycle streams.

An alternate method of demethanization, and the one employed in Gulf's second ethylene unit, involves the use of a low-temperature fractionator. The gas charge is refrigerated to a low temperature at a pressure sufficiently high to condense in part the mixture which enters this column. From this tower methane-and-lighter is taken as an overhead product, and liquid methane is used as reflux. The bottoms product is passed to succeeding fractionating columns.

A modification of this low-temperature fractionation procedure which has been employed by some companies involves the use of the oxygen-plant fractionating technique. Charcoal adsorption is another process which can be used to demethanize.

After the methane-and-lighter is removed, the ethane and ethylene can be be taken overhead in a conventional tower, except that refrigeration is required in order to condense this overhead product. The de-ethanizer bottoms contain propylene and heavier materials. This bottoms product may be recycled to the cracking furnaces, but usually any C_4's-and-heavier present will first be separated out as a product stream. Many units recycle the total C_3 stream to extinction. But, because propylene itself is valuable and because it is a less desirable material for charge to cracking furnaces which produce ethylene, it is often removed before the propane is recycled.

Propylene present in the charge to the unit, or in the recycle propane stream, may be removed in conventional fractionating equipment. This separation is relatively difficult, however, particularly if high-purity propylene is required for other petrochemical operations. Another means of recovering the propylene, and the one used by Gulf, is to charge the whole propane-propylene recycle stream through a catalytic polymerization unit, and to recover it as high-octane motor gasoline and tetramer. The propane effluent is then a more desirable feed to the cracking furnaces.

The overhead from the de-ethanizer is charged to an ethane-ethylene splitter. The ethylene product is taken overhead, and the ethane bottoms are recycled to the cracking coils.

Refrigeration

As mentioned before, ethylene manufacture is a project—"only more so." The separation of butane and *iso*butane can be achieved in conventional fractionation equipment at regular cooling-water temperatures. Such is not the case, however, with the ethane-ethylene separation, inasmuch as these materials would be above their critical temperature if conventional cooling water were employed. As a matter of fact, increasing the pressure is only a partial solution, because the separation of ethane and ethylene is pressure-sensitive in the sense that, at increasing pressures, the separating efficiency decreases sharply.

In order to provide ethylene of high purity, it is necessary to fractionate at moderate pressures, and this requires refrigeration temperatures well down in the sub-zero deg F range. Cascade refrigeration is required in order to obtain the low temperatures for the demethanization step in the processes used by Gulf, and this refrigeration may or may not be used in the ethane-ethylene separation. Here the low-level refrigerant is most generally ethane or ethylene. This, in turn, is condensed with the high-level refrigerant, usually propane, which is condensed with conventional cooling water.

Cascade refrigeration is not at all new or novel, but the fact that each level of refrigeration must be in satisfactory operation before the next lower level of refrigeration can be brought on stream compounds the difficulties in operating equipment of this type.

Once again, however, the analogy between a conventional refining unit and an ethylene unit is a matter of "only more so." Not only does a column of an ethylene unit have to be in equilibrium so that it does not upset the operation of a succeeding column, but the reflux for some of these columns cannot be obtained unless the cascade refrigeration is operating properly. Inasmuch as any ethane or ethylene used for refrigeration very probably is produced within the ethylene unit, and inasmuch as this refrigerant must be relatively pure in order to provide the control necessary in the refrigeration system, the operation of an ethylene-separation unit is a kind of "lifting by the bootstrap" operation. It is no longer a simple matter of trying to operate a group of towers in series, with each column feeding the one following. The refrigeration systems are probably interlocked, and they compound the operating problem.

In the design of an ethylene unit there is a great deal of temptation to save equipment by the interlocking of operations through a number of internal recycle streams. Often equipment is saved; and it is true that equipment saved is equipment which doesn't have to be operated. Some of these simplifications, however, can complicate the operation of the unit more than the equipment elimination can simplify it. This is particularly true during startup, because then the operator is seldom blessed with recycle streams and, especially, refrigerants of equilibrium purity.

Such variations from normal conditions are particularly important in a plant which uses centrifugal compressors. Such machines, by their general character, are very critical to changes in gas density. Like a centrifugal pump, each impeller increases pressure by so many feet of head of the fluid handled. But, unlike a pump, the density of the fluid changes through each impeller. Thus any change in density at the suction is amplified at each stage and may end up as a discharge pressure very

XUM

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different, in pounds per square inch, from that of the design. This discharge pressure cannot be compensated for by changes in quantity, as in the case of the reciprocating machine, because the head-vs-quantity curves of most of these machines are very flat. Thus the limits of variations, as well as the normal operating point, must be considered in the design of such a unit.

Cracking Operation

The dehydrogenation of ethane or the cracking of propane so as to produce ethylene is, in Gulf Oil Corporation's units and many others, achieved in a tubular coil. The tubes are fired on the outside, and the feedstock plus steam pass through the inside. The conventional thermal cracker employs a furnace whose coil outlet temperature seldom exceeds 1000 F. Once again the comparison with an ethylene unit is a matter of "only more so." Here the coil outlet temperature is some 500 F higher than that of the conventional thermal cracker. This is possible only because the feedstock is extremely clean. Althuogh clean feedstocks minimize many problems, the metals problems associated with higher tube-metal temperatures are still there.

In order to operate cracking furnaces with tube-metal temperatures above 1500 F, it is necessary to use high-alloy tubes. All tubes in this service, so far as we know, contain nickel. In Gulf's furnaces 18-8 stainless-steel tubes are used in the lower-temperature section of the furnaces. In the higher-temperature sections we have Inconel, Incoloy, and 25-20 stainless steel. Some information has been published on the relative tube life which is to be expected from some of these alloys. In our operations we feel that it will take several more years to evaluate properly these different alloys, or even to say whether or not the cost of the higher alloys is justified over 18-8. A few established facts regrading tube life which we have confirmed are:

1. Welding must be perfect.
2. Increased coking shortens tube life.
3. None of these alloys is satisfactorily self-supporting at these temperatures for distances in excess of approximately four ft.

Operation of an ethylene cracking furnace is a matter of the minimization of coking. There are probably as many ideas on how to minimize coking as there are operators of thermal cracking equipment. The principles, however, are the same for both the conventional thermal cracker, or thermal reformer, and the ethylene-producing unit. These are to keep the mass transfer up, to keep the feed clean, to maintain proper temperature gradient, and to keep charge and firing rate constant. Provision for a quenching system which is rapid and effective is essential. With much higher temperatures, much lighter materials, a substantial amount of hydrogen in the effluent stream, and no liquid condensation to aid heat transfer, the problem of quenching once again becomes a matter of "only more so."

Heater Coke Problem

The matter of coking involves the problem of reaching a proper compromise between the elimination of coke formation, inasmuch as it tends to decrease operability, and the achievement of the benefits from the higher temperatures and other conditions of higher feedstock conversion which tend to aggravate coke formation. It is not believed that it is economically feasible to try to eliminate coking entirely. Rather, we believe that the proper solution to the whole problem is a matter of learning how to live with coke formation, and then learning how to take such steps as are necessary to minimize the interference with operations which coke formation might otherwise cause.

It is thought that one of the best means of solving the coking problem in an ethylene unit is to provide extra heaters, or sufficient extra heater capacity, so that heaters may be removed from service without decrease in the capacity of the unit. Thus we have found that the proper solution to our problem is a matter of extra furnace capacity and a means of decoking the offstream heater rapidly, without the necessity of pulling it apart.

The use of a diluent such as steam in the cracking-heater tubes serves another very important purpose, totally apart from its usefulness in suppressing coke formation. Because ethylene heaters must come down at regular intervals for coke removal or repairs, the unit is most properly made up of a number of relatively small cracking furnaces.

To bring these furnaces down without effecting a substantial change in the throughput of the plant requires that fresh furnaces be brought onto the line. This is generally best achieved by bringing them up to temperature with steam passing through the tubes, and with sufficient fire in the box to achieve the necessary temperatures. Once the furnace is in approximate equilibrium, feedstock can be cut from the furnace which is being taken out of service and put into the furnace which is being placed in service, with a minimum of upset to the separation section of the plant.

A theory has been advanced that coking of the heaters is influenced by the type of materials used in the heater tubes. This theory stems from the knowledge that some materials of construction are catayltic for the formation of coke. Although we do not intend to debate the point, and tube material may be a factor in the formation of coke, we have not found a tube material which will eliminate coke formation. Therefore, although selection of the proper tube material may decrease coke formation somewhat, it is believed that spare furnaces and a means of decoking while the rest of the unit remains in operation is by far the most fundamental solution to the problem of continued operation of the ethylene-formation section of the unit.

While the decoking operation need not be mechanical, the operation of the furnaces and, for that matter, other parts of the ethylene unit requires that a great deal of mechanical work be done on the units while they are in operation, or at least while other sections of the plant continue to operate. This means that the unit should be so constructed, and so laid out, as to permit the necessary welding and other types of maintenance work to proceed even though the unit itself remains in operation.

Water Removal Essential

Almost everyone who has operated a veriety of fractionating equipment has, at one time or another, had difficulty because of the presence of water in the fractionator. In the case of an ethylene unit, the presence of water is once again a case of "only more so." Here the temperatures are sufficiently low, and the pressures sufficiently high, that any water present will form hydrates with the hydrocarbons, and these hydrates will accumulate so as to produce an ice plug which may render the column incapable of passing its required vapor or liquid load.

Methanol is used as a means of minimizing hydrate formation, if the means of getting the methanol to the proper place in the column is available. Methanol is, at best, only an emergency answer to the problem, however; complete feed dehydration is the most desirable solution.

The problem of water removal has so important a bearing on the operation of an ethylene plant that the customary procedure of steaming out for removal of hydrocarbons is not satisfactory when it comes to the starting up or shutting down of an ethylene unit. Although the steaming-out process will achieve the purging desired, the water introduced into the unit prolongs the drying-out time necessary when the equipment is started up. This, coupled with the necessity for starting a number of columns in series and

for obtaining refrigerant to get the system into equilibrium, complicates matters unnecessarily. We have found it a desirable solution to install an inert-gas generator which is equipped with driers capable of providing a low-dew-point inert gas for purging.

It is also apparent that the existence of sufficient accumulator capacity to permit storage of enough internal recycle streams of equilibrium composition is a substantial aid to the starting up of the unit after it has come down for a temporary shutdown.

Product Delivery

Gulf Oil Corporation delivers ethylene from producing units to consumers via a pipe line system which it has installed, and which serves not only Port Arthur, but also the Orange, Houston, and Texas City, Texas, areas. The operation of this pipe line is once again a matter of "only more so." In the measuring of a relatively valuable gaseous material, such as ethylene, the degree of metering accuracy required is far greater than that normally found to be adequate. For this reason Gulf has found it necessary to determine more accurate values for true gas-law deviations than those previously reported in the literature for ethylene. Ethylene pipelining and measurement, it is felt, require special installations which involve better-than-average pressure-reducing stations, orifice runs, measuring equipment, and the like.

For practical reasons an ethylene pipe line will normally operate at pressures considerably in excess of those desired by the ethylene consumers. This necessitates a substantial reduction in pressure at the meter station, and the throttling necessary may be sufficient to cool the metered stream to 0 F or lower. Although this is neither unexpected nor unusual, it does tend to introduce another problem into the accurate metering of the amount of ethylene delivered, and suitable equipment must be installed in order to minimize this problem.

Both operations and maintenance of the ethylene pipe line are handled by the pipe line department of Gulf Oil Corporation. Coordination and operational control of the line rest with the 24-hour-per-day dispatching center in Gulf's Houston pipe line offices. Private-line telephone service is available from this center to each customer or Gulf facility which has a metering station handling ethylene.

The elements of a dependable ethylene supply are a stable raw-material source, a well-operated plant, and a substantial surge capacity for the finished product. The operating problems discussed herein are those of a general type which must be solved if any installation for the large-scale production and distribution of ethylene is to be well operated. Although we have confined our observations to problems which can be expected to be typical of any ethylene-producing plant, we wish to point out that any specific unit will have its own peculiarities. Many of these are more properly classed as operating nuisances. Finally, many of the troubles which an ethylene-plant operator will encounter, and which tend to disrupt the continuity of ethylene production, will stem from mechanical failures. These problems will be found in any unit and—like the forgotten gasket or the lunch box in the suction line—they are not characteristic of the process itself. * * *

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API Research Sweeps Away Petroleum "Mysteries"

WITH seven of the Fundamental Research Projects reporting to the annual meeting in Chicago, Illinois, this very important program of the API's activities is bringing to light more and more fundamental data. Among the projects reported on are:

NO. 52—Nitrogen in Petroleum;
No. 48—Sulfur in Petroleum;
No. 45—Synthesis, etc., of Hydrocarbons;
No. 44—Data on Hydrocarbons;
No. 50—Thermodynamic Properties of Hydrocarbons;
No. 6—Analysis, Purification, etc.
No. 42—Synthesis of ***High-Molecular Weight Hydrocarbons.

Prominent in these data the sulfur and nitrogen compounds found in petroleum. Nitrogen compounds affect seriously the refining (treating) storage and the utilization properties of hydrocarbon fractions. Catalysts lose activity in the presence of nitrogen compounds. Gasoline yields by catalytic methods are reduced seriously. Pyrolle, an organic nitrogen compound affects largely the storage stability of burner, diesel, and similar fractions. Nitrogen forms lacquer on piston rings and carburetor gum deposits; causes color formation, it is believed, and nitrogen-metal prophyrins bring in metal poisons to catalysts. Shale oil refining in future will be aided by the facts now being discovered.

Nitrogen occurs in quantities from traces to 0.9 per cent, the latter in some California crudes; the late J. R. Bailey went to California refiners for nitrogen-high stocks for research. The more asphalt the crude, and the higher the boiling range of a fraction, the higher the nitrogen content. Most of the nitrogen cannot be extracted with dilute acid (by metathetical reactions forming ammonium, amine- or similar salts).

Because of the importance of Bailey's work—40 quinoline and pyridine homologues have been segregated and identified at the University of Texas—this present project will be confined largely to non-basic types of nitrogen organics. Three main divisions of the work are:

Chemistry of Nitrogen Compounds—University of Kansas.

Nitrogen Compounds in Petroleum—Bureau of Mines, Laramie, Wyoming.

Thermodynamic Properties of Nitrogen Compounds—Bureau of Mines, Bartlesville, Oklahoma.

Project 48 has developed methods for the synthesis of thiols, adding thiolacetic acid to olefins, then hydrolyzing. Since 1952 ten sulfur compounds of 99.9-plus purity have been prepared in considerable amounts and 35 more in small quantities. The 10 have been added to the earlier 20 compounds available on API distribution lists. Ninety-one small samples have been investigated spectroscopically, with 212 determinations, which spectra are available through Project 44. Measurement and/or calculations of thermodynamic properties are completed or in progress on 27 sulfur compounds.

Two-hundred and ninety-six hydrocarbons have been synthesized in the 16-year life of Project 45; this totals 422 gal of pure compounds at an average cost of $1400 per gallon. Currently unsaturates are under emphasis. Most of the members of the hexane and heptane families are completed or nearly so.

Fifty-nine cycloparaffins have been engine tested.

In Project 50, emphasis has been on theoretical methods for obtaining thermodynamic data that permit calculation of the data for a whole series of compounds when the key parameters have been determined.

To help true science the API sends complete sets of data from Project 44, Data of Hydrocarbons, etc., to various groups in the United States and in 26 free-world countries—universities, free libraries, non-profit research institutions, and government organizations.

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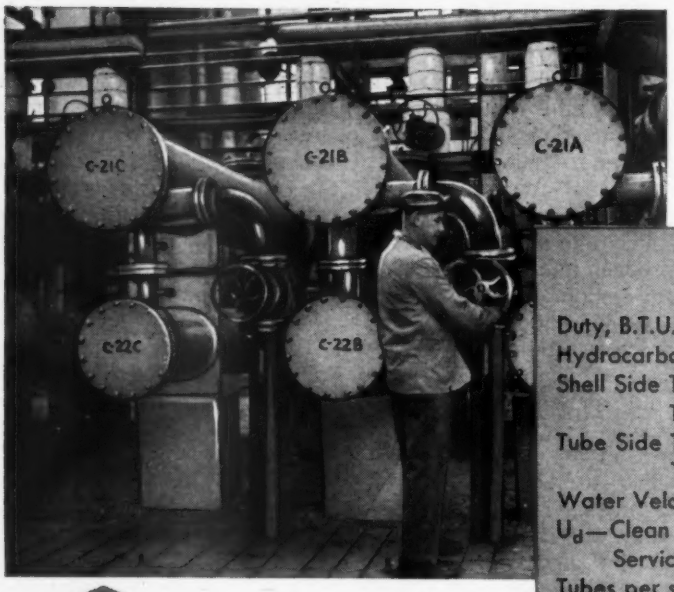

THIS UNIT consisting of three Trufin condensers and three plain tube subcoolers—is installed at a large synthetic rubber plant.

More than Met Design Requirements

		BY OBSERVATION	
	Design	Condensing and Cooling*	Condensing Only
Duty, B.T.U. per hour	8,200,000	16,680,000	10,110,000
Hydrocarbon Flow, lbs/hr	56,800	99,700	69,500
Shell Side T-in	136°F	138°F	136°F
T-out	136°F	92°F	128°F
Tube Side T-in	70°F	49°F	69°F
T-out	120°F	110°F	125°F
Water Velocity, F.P.S.	5.6	9.4	6.2
U_d—Clean	188		
Service	106	156	155
Tubes per shell	292		
Tube length, feet	16		
Surface, Square Ft.	2120		
Tube Material	¾—90-10 Cupro-Nickel Trufin 195065-53		

NOTE: The condenser in this case is carrying all the subcooling load as well as condensing. The Trufin units have always done this without difficulty.

. . . and, as outlined in the data chart shown above, far exceeded the performance specified for this installation.

The unit was designed for condensing a minimum of 136,200 pounds per hour of vapor consisting of 90% butylene and 9% butane while using two of the three parallel circuits. Although each condenser was designed for a heat duty of 8,200,000 BTU's per hour, condensing loads as high as 16,680,000 BTU's per hour were noted in condensing and cooling operations. When condensing alone was handled, heat transfer achieved was 10,110,000 BTU's per hour—a substantial increase.

Factors contributing to this increase are Trufin's ability to withstand fouling (the shell sides of these units have never required cleaning), and the resulting increase in close control of transfer by control of water volocities. Also, Trufin with its increased surface area permits greater heat transfer to be packed into condensers. And because its fins are integral with the tube wall, Trufin never drops in efficiency because of fins loosened by vibration, high temperatures or pressure changes.

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Electric Mercaptan and Amine Salt-H_2S Processes

Reduction of desulfurization costs and of stream pollution hazards claimed

OLIVER J. SANDONA* and CHARLES W. RIPPIE**

THE operations of a modern refinery presents many technical problems of a chemical nature. A very important one is the treatment of gasoline for sulfur removal to effect improvement of odor, storage stability, tetraethyllead response, gum content, and other sales specifications. Recent trends toward processing higher sulfur crude oils further emphasize the need for low cost treatment.

Sulfur as mercaptan sulfur has been removed from gasoline for a good many years by the use of caustic solutions. Sulfur as hydrogen sulfide has been removed from refined products by a combination of fractionation and caustic soda wash. In cases where fractionation does not lend itself readily, a regenerative amine or phosphate solution is used. These are particularly good in case of high concentration of hydrogen sulfide.

The use of caustics for the removal of hydrogen sulfide has created a waste material difficult to dispose without causing a stream pollution problem. Refiners today are conscious of the stream pollution problems confronting industry. The steady growth of large industries and the increase in centralized population during and after World War II has resulted in considerable legislative activity. It appears that stronger abatement measures are inevitable.[1]

It is the purpose of this article to present a new development in the regeneration of caustic soda solutions containing mercaptans and hydrogen sulfide. The regeneration of spent caustics is accomplished by the use of external atomic oxygen oxidation utilizing the electric process.

It is also proposed to describe a new development of the amine salt-H_2S process, for the extraction of hydrogen sulfide from hydrocarbon streams. The use of the above processes will reduce substantially the chemical pollution of streams experienced by many refiners. Both plant operators and management will find these processes simple and economical solutions to a chemical treatment problem.

*Ashland Oil and Refining Company.
**Electric Process Company.
†Presented before Western Petroleum Refiners Association, Casper, Wyoming, September 23, 1954.

Mercaptan Extraction

Process and Plant Description. Caustic soda solutions used to extract mercaptans in absorbtion columns require regeneration for economic reasons and to avoid stream pollution. Methods which have been employed are steam stripping, air oxidation, and the electric process utilizing atomic oxygen.

Conventional equipment of packed towers, mechanical mixers and settlers are commonly used for the extraction process while the regenerative equipment of the electric process[18] will be described more completely.

Although there is considerable similarity to the process of regeneration of sodium mercaptide and sodium sulfide, normally two units are employed. The presence of sodium sulfide in caustic soda adversely effects the maximum extraction of mercaptans from gasoline. The use of common oxygen generating facilities requires only minor additional equipment to operate separate sodium mercaptide and sodium sulfide regenerative systems.

Sodium Mercaptide Regenerative Equipment. The electric process equipment consists of a commercial electrolyzer for the generation of oxygen and hydrogen, an eductor for the injection and mixing of atomic oxygen, a retention tank utilized to maintain residence time, pumps, and necessary piping and instrumentation.

A new installation being constructed by Ashland Oil and Refining Company will employ the Chemico cell which is a unipolar or tank type cell operating at high amperage up to 10,000 amperes. The cell tank contains 8 anodes and cathodes constructed of Armco iron nickel plated. Each plate is separated by an asbestos diaphragm. Oxygen collectors are mounted above the anode plates, whereas hydrogen collectors are mounted above the cathode plates. Electrical energy is supplied by a General Electric Selenium Rectifier. The complete oxygen generating equipment is housed in a pressurized building to eliminate hazards of non-explosion proof equipment in the process area.

The flow diagram of the electric mercaptan process, Fig. 1, indicates the flow of caustic soda solution in the regeneration section, and sour gasoline in the extraction section.

The size of oxygen generating equipment is dependant upon sulfur load contained within the generating caustic solution or the extraction efficiency of the treating section. Utilizing the Chemico cell efficiency of 90 per cent, it is expected that 0.5 to 0.7 of mercaptan sulfur per kilowatt will be oxidized with the unit described.

Process Flow. Referring to Fig. 1, spent caustic from the absorbers is charged into the spent caustic tank. The spent caustic is utilized as a charge tank for the regenerator. Spent caustic is pumped into an eductor that is located within close proximity of the cell in order to minimize time lapse for the atomic oxygen generated to mix with the spent caustic soda. The atomic oxygen catalyses and reacts in the oxidation of mercaptan sulfur bearing caustic solution to form the disulfides later removed.

The effluent of the eductor is charged into a retention tank where contact time is maintained under pressure to afford further oxidation reaction. The effluent of the retention tank passes to the regenerated tank where disulfides are separated by gravity and periodically removed. The regenerated caustic solution is then passed through a naphtha wash to remove last traces of disulfides. The regenerated caustic solution leaving the naphtha scrubber is reused for mercaptan extraction from the sour gasoline.

Operating Data. Electric mercaptan process using the external oxidation of mercaptides has operated at the Ashland Oil and Refining Company No. 1 plant. More than 500,000 bbl of gasoline have been treated with the same caustic soda solution with satisfactory results. A typical plant total sulfur balance is indicated in Table 1. All electrometric titrations for mercaptan sulfur and sulfide sulfur used Shell's Methods 177/51 in gasoline and 304/49G in aqueous solutions, respectively.

The amounts of acid oils and sulfur derivatives of these compounds increased with the development of catalytic cracking operations. The existent gum test ASTM D318-52T (glass dish) determines the amount of non-volatile residue in the time of the test. The re-

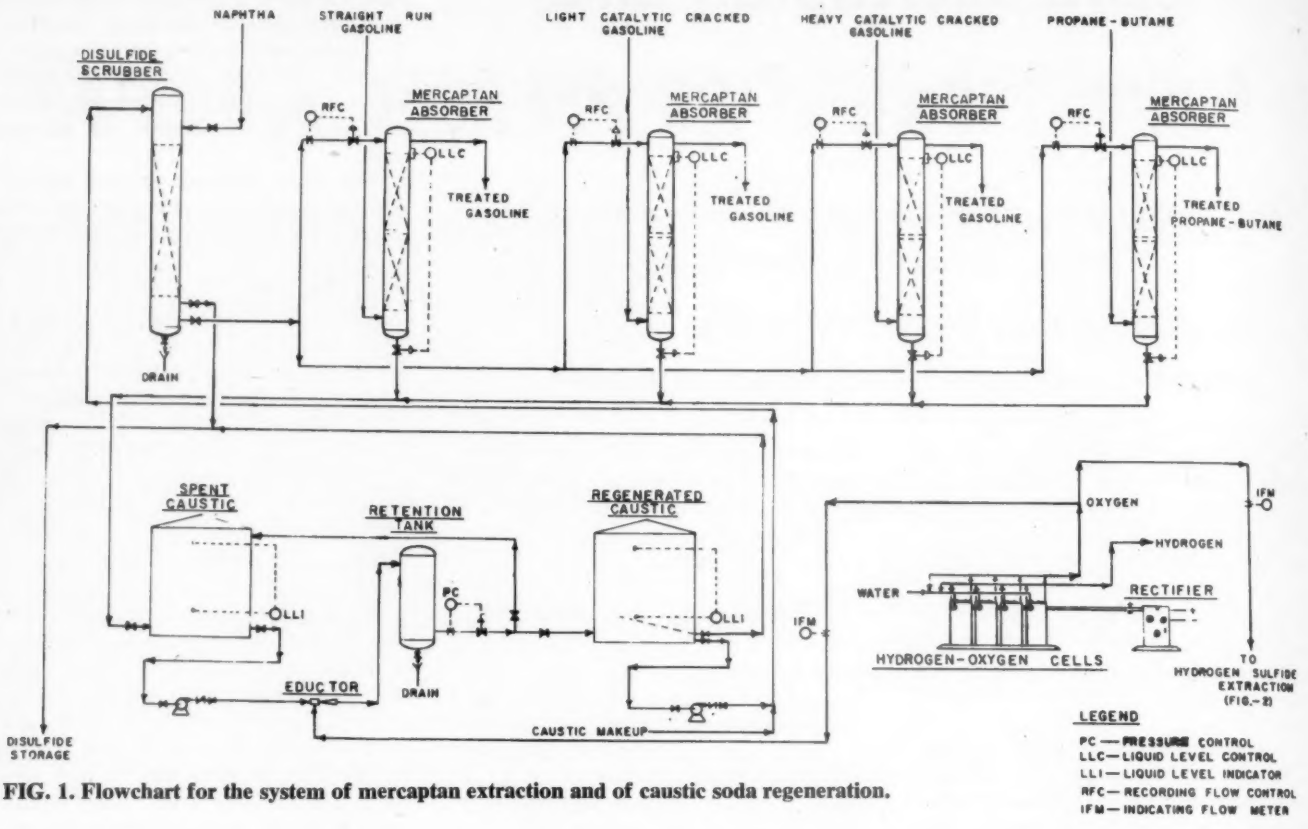

FIG. 1. Flowchart for the system of mercaptan extraction and of caustic soda regeneration.

moval of the acid oils by caustic washing has been found to reduce glass dish gums to satisfactory low values. As a result, treatment of catalytic cracked gasoline consumes large amounts of caustic soda. Caustic soda solutions of high acid oils content increase plant disposal problems. Flue gas neutralization has been developed over the industry, but is not considered a complete solution.

Recently Leonard Refineries, Inc., of Alma, Michigan, installed the electric process to oxidize mercaptan sulfur compounds in spent caustic soda solutions to disulfide sulfur compounds. This refinery reduced caustic consumption at least 75 per cent, stopped caustic disposal from TCC treating operations, reduced inhibitor requirement, improved glass dish gum, and left the cresols in the treated gasoline.

The extraction of thiophenols is believed to be contributing to the reduction of glass dish gums from 6 Mg/100 ml before treatment to less than 2 Mg/100 ml after treatment without the use of an inhibitor. Recently Cabal[10] reported that high glass dish gums may be related to manifold deposits in automotive engines. This excellent paper on gasoline stability did not state that the added cresols in glass dish tests were free of thiocresols. It is pointed out, however, that antioxidant sweetening of gasoline may tend to form peroxides and to increase manifold deposits under some conditions. The overall plant balance is indicated in Table 2.

Hydrogen Sulfide Extraction

Process and Plant Description. Caustic soda solution is usually employed to extract small concentrations of hydrogen sulfide from liquid hydrocarbon products. A few of the methods for the disposal of foul caustics include lagooning, neutralization with spent acids or flue gas, oxidation with air and steam,[3,4,5] None of these methods presents a means for reuse of the caustic through its regeneration.

The regeneration of foul caustics through external oxidation has been successfully accomplished by Ashland Caustics containing sodium acid sulfide or sodium sulfide treated with atomic oxygen will regenerate to free caustics and sulfur complex. Small amounts of mercaptan sulfur within the system are converted to the disulfides which absorb or react with free sulfur to form polysulfides.

Sodium Sulfide Regeneration Equipment. The oxygen generating equipment for foul caustic regeneration is identical to the unit described for the regeneration of mercaptan sulfur. Normally a common charge effluent drum

TABLE 1. Mercaptan extraction and caustic regeneration.

Material	Straight run gasoline	Thermal cracked gasoline	Caustic solution
	Operating data		
Flows, B/D	3500.	4500.	1600.
Gravity	67.0 deg API	57.0 deg API	20.0 deg API
RVP, psig	8.1	6.5	
Distillation			
Initial, F	101.	106.	
End point, °F	310.	380.	
Mercaptan sulfur, wt. per cent			
Sour	0.012	0.007	
Treated	0.009	0.004	
Spent			0.132
Regenerated			0.120
Sulfide sulfur, wt. per cent			
Sour	0.008	0.0	
Treated	0.0	0.0	
Spent			0.073
Regenerated			0.061
Extraction and regeneration			
RSH lb/day	30.0	50.0	77.0
H_2S lb/day	80.0	0.0	77.0
Power			
Cell KW/day			528.0

TABLE 2. Mercaptan extraction and caustic regeneration.

Material	TCC gasoline	Caustic solution
	Operating data	
Flow, B/D	2000.0	580.0
Gravity	51.8 deg API	17.0 deg API
Acid oils, per cent volume		27.0
RVP, psig	9.5	
Distillation		
Initial, F	110.0	
End point °F	424.0	
Existent gum, mg/100 ml		
Sour	6.0	
Treated	2.0	
Mercaptan sulfur, wt per cent		
Sour	0.0176	0.124
Treated	0.0036	0.100
Per cent reduction	80.0	24.0
Extraction and regeneration		
Mercaptan sulfur lb/day	55.1	54.0
Power		
Cell KW/day		360.0

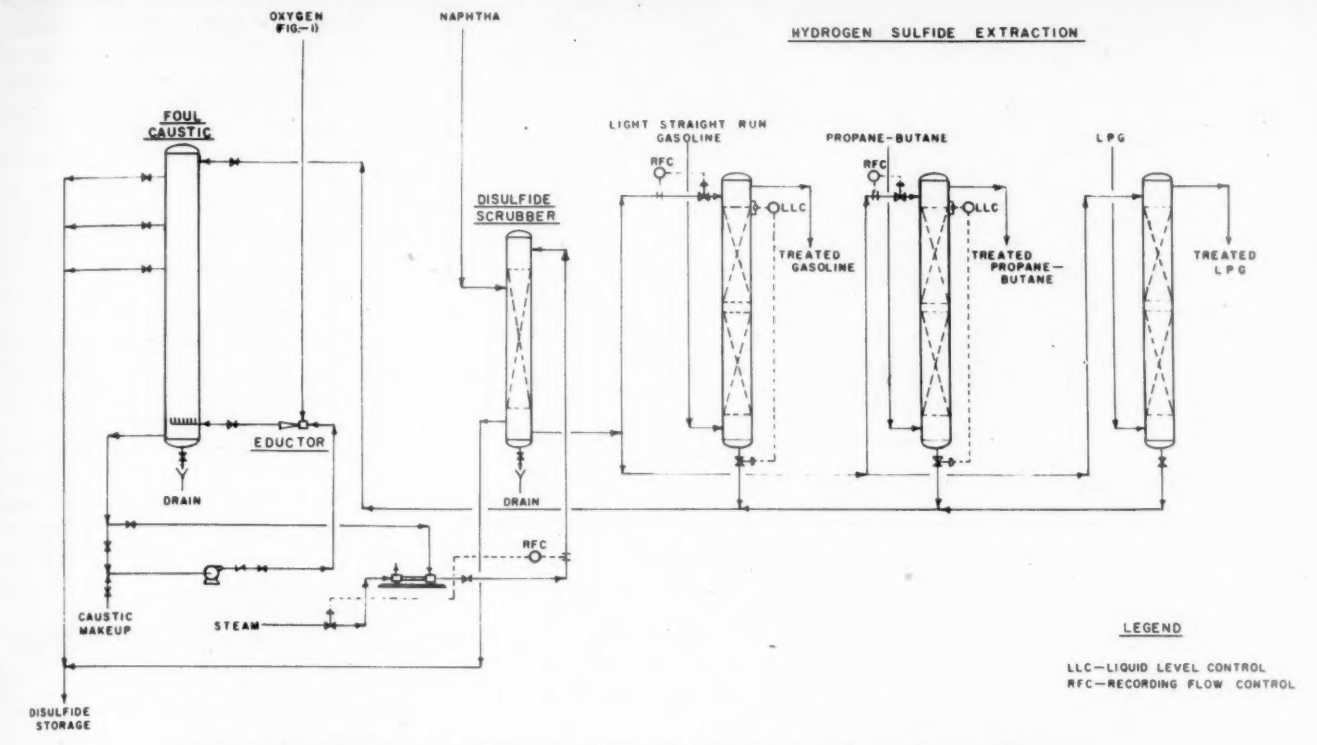

FIG. 2. Simplified chart for hydrogen sulfide extraction and caustic soda regeneration.

is employed along with an eductor, pumps, and necessary piping and instrumentation.

Process Flow. The flow of caustic in the hydrogen sulfide extraction unit is shown in Fig. 2. Conventional packed towers are employed for the extraction of hydrogen sulfide from the hydrocarbon streams. The flow of caustic soda from the extraction tower is charged into a common regenerator charge effluent drum. The recirculation of caustic soda acts as a vehicle for atomic oxygen addition. Thorough mixing in the process is accomplished at the eductor, and the distribution within the foul caustic tank. The sulfur and polysulfides formed in the reaction are removed from the foul caustic tank. The regenerated caustic is reused for extraction of hydrogen sulfides following washing in a naphtha solution to remove the last traces of polysulfides.

Operating Data. The regeneration of foul caustic in a block out operation was tried to determine the regeneration of concentrated sodium acid sulfide solutions. One hundred forty barrels of spent caustic was pumped into the regeneration unit and circulated. Results of the test indicated that sodium sulfide was converted to sodium hydroxide. Sufficient mercaptans were present that it is believed the free sulfur formed reacted with the disulfides to yield polysulfides. No evidence of collodial or free sulfur was noted. The test results are indicated in Table 3, after 48 hours of operation. All electrometric analyses were made with the Shell Method 275/51 for alkalinity for free NaOH solutions.

The mechanism of oxidation reactions for the mercaptides and sulfides depends upon the presence of atomic oxygen. The generation of oxygen in the electrolytic cell affords the presence of atomic oxygen in abundance with its equilibrium of various isotopes.[6,7] It is recognized that many electrochemical books[8] report that external electrolytic oxygen is molecular oxygen. Investigations, however, reveal that the time factor was never measured.

The electric process incorporates in its design the use of atomic oxygen to oxidize sulfides. Molecular oxygen in air or in oxygen cylinders converts sulfide sulfur to sodium thiosulfate and sodium sulfate very slowly, even at elevated temperatures and long contact time.[9] No free caustic is recovered. Reactions for electric process are:

TABLE 3. Sodium sulfide regenerative test data.

Material	Spent caustic	Regenerated caustic	Net change
Capacity, bbl	140.0	140.0	
Analyses; mole/liter			
Sulfide sulfur	0.750	0.320	
Mercaptan sulfur	0.125	0.062	
Free NaOH	0.981	1.454	
Results:			
Free NaOH, increase lb			980.0
Sulfur, decrease, lb			774.0
Power KW	960.		

$$2NaSR + H_2O + O = R_2S_2 + 2NaOH$$
$$Na_2S + H_2O + O = 2NaOH + S$$
$$R_2S_2 + S = R_2S_3$$

Operating Costs. The unit operating costs for the regeneration of spent caustic soda solutions are low. Normally, with automatic controls, operating attention of one-third man days is adequate. Utility costs are the electrical consumption of the rectifier, pumps, and unit lighting.

Justification for Plant Installation. The justification for the installation of a complete caustic soda regeneration and sulfur extraction facilities may be based on the following items:

1. Increase in gasoline tetraethyllead susceptibility.
2. Decrease in caustic consumption.
3. Decrease in inhibitor requirements.
4. Low operating costs.
5. Decrease of waste disposal problems.
6. Negligible corrosion experienced with low temperature operations.
7. High on stream time.
8. Consistant quality products.
9. Decrease glass dish gum for catalytic cracked gasoline.

A complete study of each individual refinery problem, keeping in mind the above items, will result in obtaining a rapid payout period for a unit installation.

Amine Salt — H_2S Process

The increased sulfur content of proc-

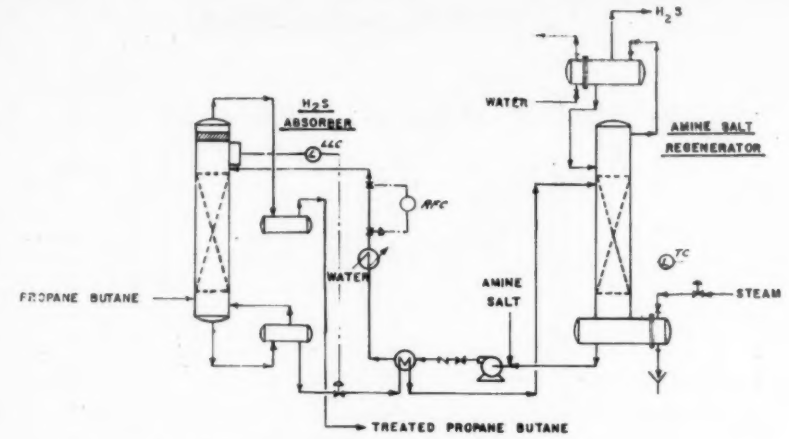

FIG. 3. Amine Salt — H_2S processflowchart.

essed crude oils and natural gases increases the need for chemical treatment to remove hydrogen sulfide. Since the early days of the Girdler Process, the advantages and the disadvantages of the amine process have been well known in the refining industry.[10,11,12,13,14,15,16] Corrosion and chemical consumption constitute the major costs of the amine process.[17]

Limited amount of technical data are available at this time on the new amine salt—H_2S process. The advantages of the new process are:

1. Reduced corrosion of regeneration equipment.
2. Reduced solubility of the solvent in the liquid hydrocarbon treated without the sacrifice of hydrogen sulfide absorption capacity.

Controlled laboratory tests show that the amine salt had only 10 per cent of the corrosion rate compared to similar diethanilamine solution. Carbon steel strips were exposed to salt and diethanolamine solutions under reflux of a 24-hour period. Results of the tests are indicated in Table 4.

The importance of elementary sulfur recovery from hydrogen sulfide extraction processes has made extensive use of the amine regenerative process. The large make-up requirements of chemicals in the amine salt process constitute appreciable expense.[16] It is reported that amine solutions have various solubilities in light and heavy liquid hydrocarbons.

Some commercial amine plants lose 20 to 40 lb of amines per 1000 bbl of liquid hydrocarbon treated. Salt solutions are considerably less soluble than amines in poly feed stocks and gasolines. Although the present unit price of amine salt solution is higher than amines, the reduced solubility and corrosion should give a favorable pay out for the amine salt—H_2S process.*

It is planned to operate the new process shortly to remove hydrogen sulfide from liquid poly feed stocks. The operating cycle of the amine salt —H_2S process is shown in Fig. 3. Countercurrent extraction is employed utilizing a packed column. The regeneration of the amine salt solution is accomplished by stream stripping. This new process can easily operate ahead of the electric mercaptan plant to provide low cost overall treatment.

A comparison of diethanolamine and salt solutions is shown on a unit basis as follows:

	DEA	Salt solution
1. Corrosion, mg loss	1.00	0.10
2. Solubility, wt.	1.00	0.10
3. H_2S capacity, gr/gal.	1.00	1.00
4. Boiling point, F	216.	222.
5. Unit chemical cost	1.0	2.0

TABLE 4.

Material	Concentration per cent volume	Boiling point F	Time hours	Loss of weight	Condition of coupon
Amine Salt	30	222	24	0.7	Tarnished by reflux
Diethanolamine	20	216	24	10.0	Pitted at liquid level

Conclusion

The advent of the development of the electric mercaptan process, the electric hydrogen sulfide process, and the amine salt—H_2S process will afford the refiner new tools to obtain low cost desulfurization and to combat stream pollution.

The extraction of mercaptan sulfur from gasoline yields many benefits of improved odor, storage stability, response to tetraethyllead for octane improvement, and inhibitor for stability. Caustic soda is used for the extraction of acid oils from catalytic cracked gasoline to reduce glass dish gums. The consumption of caustic soda results in a problem of spent chemical disposal.

The use of the electric mercaptan process has resulted in selective extraction of the thiophenol resulting in low glass dish gum and subsequent elimination of a disposal problem. The oxidation of mercaptides to disulfides in caustic soda solutions by atomic oxygen affords an economic process easily evaluated for quick pay out.

Caustic soda used for the removal of H_2S from hydrocarbons may be reused after the conversion of the sodium sulfide to free caustic. The use of the electric H_2S process will eliminate the problem of foul caustic disposal.

The disadvantages of the well known amine process for H_2S removal have been high chemical consumption and corrosion. Laboratory evaluation of the new amine salt—H_2S process indicates advantages over the present known amine process through low liquid hydrocarbon solubilities and decreased corrosion.

*The Amine Salt is available from General Amiline and Film Corporation, New York, in commercial lots.

Acknowledgment

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Losses in TEL efficiency from sulfur compounds are additive when each compound is reduced to a common denominator

CHARLES E. FISKE* and RALPH MILLER**

PRIOR to treating, substantially all gasoline contains greater or lesser amounts of dissolved mercaptans. Mercaptans in gasoline are objectionable for at least two reasons—they have a foul odor so that their presence in more than minimal amounts is objectionable to the consumer and they are objectionable to the refiner because they add to his tetraethyl lead bill.

Although it is general knowledge that sulfur decreases the efficiency of tetraethyl lead, a clear cut relationship does not exist between the total sulfur content of a stock and the increased lead requirements occasioned by the presence of the sulfur. Fig. 1 taken from the work of Pulleyblank and Lovell[1] shows that sulfur affects the antiknock efficacy of tetraethyl lead and that the effect depends upon the type and concentration of the sulfur compounds present. These authors assembled most of the published quantitative work in this field, averaged it with their own work and constructed these curves. The present writers only added the ordinates on the left hand.

It will be seen that if a sulfur-free gasoline requires $1 worth of TEL to secure a necessary octane number improvement, that same gasoline will require about $1.12 worth of TEL if it contains .006 weight per cent of thiophene sulfur. If the gasoline contains the same concentration of sulfur in the form of mercaptan sulfur, it will require $1.43 worth of TEL to obtain the same improvement. If the gasoline is sweetened so that the mercaptans are converted to disulfides, it will still require $1.43 worth of TEL to secure the necessary improvement. It is clear that over the range of sulfur concentrations of commercial interest sweetening will not affect the lead response of mercaptan-containing fuel.

It will be observed that .04 per cent of thiophene sulfur in a gasoline will cause a loss in lead efficiency of 30 per cent (100-70). This same loss in efficiency will be caused by .006 per cent of mercaptan or disulfide sulfur. Hence, .04 per cent of thiophene sulfur is equivalent to .006 per cent of mercaptan or disulfide sulfur. By means of these curves it is possible to convert the concentration of each of the various sulfur compounds shown to its equivalent of any of the others on the graph.

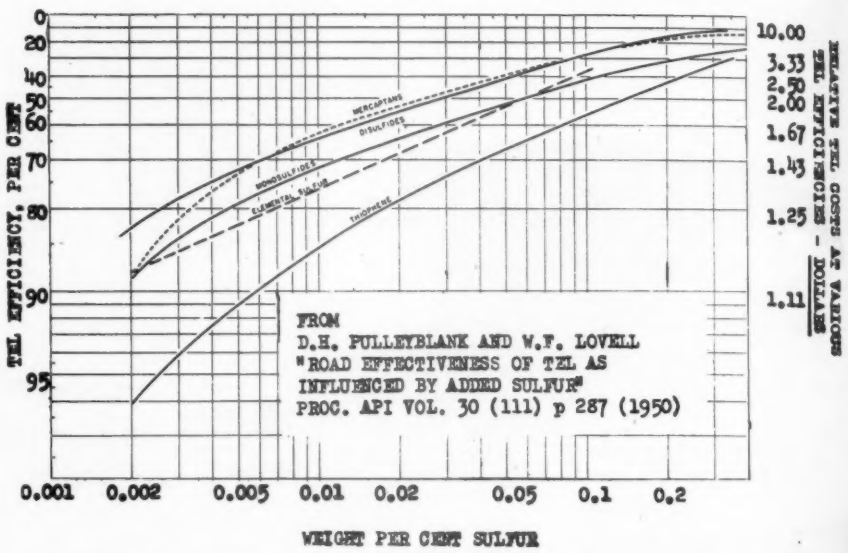

FIG. 1. Effect of sulfur compounds on TEL efficiency in low-sulfur base fuels.

It has been demonstrated that the loss in TEL efficiency caused by the various sulfur compounds contained in a gasoline are additive[2] when each is converted to a common denominator. For example, the concentration of each sulfur compound present may be converted to its equivalent concentration of disulfide sulfur and the various equivalent concentrations totaled. By referring to the disulfide curve, the loss in TEL efficiency of the blend can be estimated.

If means are available for diminishing the concentration of one or more of the sulfur compounds in the blend, these curves permit one to estimate what the potential savings in TEL will be, if the reduction is achieved.

Of the various sulfur compounds present in a gasoline only the mercaptan sulfur concentration is easily reduced by simple extraction. If the mercaptan sulfur concentration of a gasolin represents a high proportion of the total sulfur in a fuel, then the removal of a substantial percentage (e.g. 65-90 per cent) of the mercaptans will mean appreciable lead savings. When the mercaptan sulfur represents a small percentage of the total sulfur present, the savings in lead will be difficult to measure directly on a CFR engine even if the mercaptans are completely eliminated. It follows, then, that the change in lead response of a stock as a result of a reduction in mercaptan concenration will be affected both by the type and concentration of the other sulfur compounds present and the degree to which the mercaptans are removed.

Pulleyblank and Lovell's paper contains a compilation of the sulfur type analyses of 11 base fuels. Using the curves in Fig. 1 these authors converted each concentration of sulfur compound present to its equivalent disulfide sulfur concentration. The figures were averaged and are reproduced as Table 1. If it be assumed that the total of .022 per cent of disulfide sulfur

*Leonard Refineries, Inc.
**American Development Company.
†Presented at Western Petroleum Refiners Association, Alma, Michigan, June 24-25, 1954.

TABLE 1. Sulfur type analyses*

Total sulfur	.091	Disulfide sulfur equivalent
H_2S	.000	
Elemental	.001	
Mercaptan	.000	
Disulfide	.022	.022
Sulfide 1	.011	.0058
Sulfide 2	.020	.0033
Residual	.038	.0058
Total of all sulfur species	.092	.0369

Sulfide 1—Removable by mercurous nitrate
Sulfide 2—Removable by mercuric nitrate
* Average of 2 base fuels, per cent by weight
Per cent loss in TEL efficiency — 55 per cent.

TABLE 2.

Per cent of mercaptan extracted	0.0	75	100
Per cent disulfide sulfur equivalent in fuel	.37	.02	.015
Per cent loss in TEL efficiency	55	45	40
Ml of TEL required to achieve desired octane	3.00	2.45	2.25
Ml of TEL required to overcome sulfur antagonism	1.65	1.10	0.90
Ml of TEL useful in improving octane no. of fuel	1.35	1.35	1.35
Relative cost of TEL fluid	2.30	1.85	1.67
Estimated TEL costs per 1000 bbl of gasoline, dollars	277	218	208

shown was originally .022 per cent of mercaptan sulfur that was converted to disulfide sulfur by sweetening, it is instructive to determine the possible TEL saving by removing either 75 or 100 per cent of the mercaptans by extraction.

By means of these curves it is possible to obtain an estimate of what the percent loss in TEL efficiency would be in the 3 cases. These figures are shown in line 3 of Table 2. If it is necessary to use 3 ml of TEL per gallon of fuel to secure the desired octane number without mercaptan extraction, a smaller quantity will obviously be needed if some or all of the mercaptans are removed. The quantities required in each instance are shown in line 4. The bottom column indicates TEL costs per 1000 bbl of gasoline at the present cost of TEL fluid.

It will be noted that the extraction of 75 per cent of the mercaptans from the gasoline would have meant a saving of nearly $60 in the cost of TEL per M barrels. Increasing the extraction to 100 per cent removal would mean a potential saving of only an additional $10 per 1000 bl. As the cost for removing mercaptans rises progressively for similar increments, it is necessary to balance the cost of additional mercaptan removal with the benefits to be secured thereby. Although in some cases it may not be possible to measure the effect of mercaptan removal, it is probable that any decrease in mercaptan sulfur concentration will result in some lead savings.

While in some instances, measurable lead savings will not be achieved by the extraction of mercaptans, an extraction process may provide the least expensive way of improving the stock from a customer acceptability standpoint. If the mercaptan sulfur content of a stock constitutes some reasonable proportion of its total sulfur content, then as mentioned previously, it is probable that it will be economically advantageous to to use an extraction process. This is obviously the case when the cost of the extraction process does not exceed the cost of sweetening and extraction provides an acceptable product. In other instances the most economic course may be to use an extraction process followed by sweetening. The choice between sweetening alone, extraction plus sweetening, or extraction to the point where the remaining mercaptans do not cause customer complaints, can only be made by comparing the costs of each alternative including the cost of TEL.

Mercaptans are weak acids. Hydrocarbons are substantially neutral. Because mercaptans are weak acids, they are much more soluble in aqueous alkaline solutions than the hydrocarbons with which they are associated in petroleum fractions. When a mercaptan-containing hydrocarbon mixture is intimately contacted with an aqueous alkaline solution, a part of each of the mercaptan species present in the initial mixture will pass from the hydrocarbon phase to the aqueous phase. Many factors determine the extent of the transfer of the mercaptans from the hydrocarbon phase to the aqueous phase.

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affinity for mercaptans, it is not generally economically feasible to discard the aqueous solution after its initial contact with the hydrocarbon phase. For this reason it is necessary, by some means or another, to diminish the mercaptan concentration of the separated aqueous phase so that it may be reused in the hydrocarbon extraction step. By removing all or a part of the mercaptans from the separated aqueous solution, the mercaptan reduced solution is reconditioned or regenerated for additional use.

The mercaptan concentration of aqueous alkaline solutions can be reduced by various methods. One effective method consists of converting mercaptans to disulfides and separating the disulfides from the aqueous solution. In the ADC process the conversion of the mercaptans to disulfides is accomplished electrolytically. The first commercial application of the electrolytic conversion of mercaptans to disulfides was described in 1952.[3]

Theory of Cell Operation

Mercaptans present in an aqueous solution are largely combined with the cation in the form of a mercaptide salt. Mercaptide salts being the salt of a strong base and a weak acid are only slightly ionized. When an alkaline solution containing dissolved mercaptans is contacted with the anode of an electrolytic cell, some of the mercaptans are converted to disulfides.[4]

$2RS = RSSR + 2$ electrons . . a

If the solution contains only a small concentration of mercaptides, which is the case when the reaction is being used commercially, all of the anode current is not employed as indicated in equation a. The balance of the current is consumed in the formation of oxygen gas. This anode reaction may be written

$4\ OH = O_2 + 2H_2O + 2$ electrons

. . . . . b

Hydrogen gas is evolved at the cathode.

If the disulfides that are formed at the anode are permitted to contact the cathode or to intimately contact the hydrogen gas formed at the cathode, they are reduced. This would convert the disulfides back to mercaptans. To prevent this from happening commercial cells are designed and operated so that the anode products will not enter the cathode compartment and the hydrogen gas evolved at the cathode has no opportunity to reach the disulfides. This is accomplished by separating the electrodes with a diaphragm sufficiently permeable to the electrolyte that the electrical resistance is kept at a minimum while preventing the hydrogen gas from contacting the disulfide.[5]

Cell Description

To date all of the large scale installations of the ADC process have employed a filter press type of electrolyzer consisting of a series of bipolar, recessed plates, each plate having a hole in each corner. The arrangement is depicted in Fig. 2. When the entire assembly is pressed together, there are four headers running the length of the unit. Prior to tightening, a diaphragm is placed between adjacent plates. This arrangement divides the space between the electrode surfaces into an anode compartment and a cathode compartment. The two lower headers are used as inlet headers and the upper headers are employed as outlet headers.

Each anode compartment is connected to the anolytic inlet header and the anolyte outlet header by suitably drilled passageways. Each cathode compartment is connected to the catholyte inlet header and catholyte outlet header in a similar manner. The inlet and outlet headers are so planned that the electrolyte flows into each compartment close to the bottom, then up and diagonally across into the outlet header. By having the electrolyte take the described flow path, the gas formed at each electrode is readily swept out of the cell by the flowing electrolyte. The end plates are connected to a suitable source of direct current. To date, this has been the dc output of a selen-

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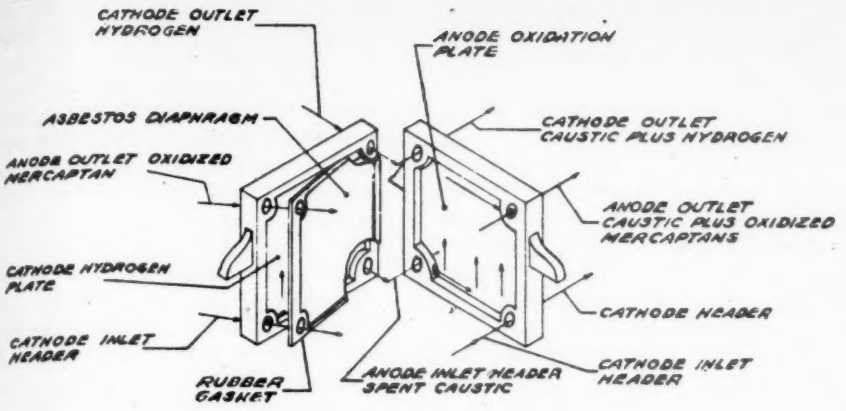

FIG. 2. Electrolyzer assembly for ADC process.

ium rectifier. This puts each of the cells in series electrically and in parallel in a solution flow path sense.

Description of Process

Fig. 3 diagrammatically depicts the process. Solution is pumped from the spent extractant surge drum into the electrolyzer through the two inlet headers. The circulation rate through the cathode compartments is controlled to continuously remove the hydrogen that is formed. This has the effect of keeping the voltage at a minimum. The catholyte leaving the electrolyzer is accompanied by hydrogen formed in the cells. Provision is made to disengage the solution from the gas and the solution is returned to the spent extractant surge tank. The anolyte leaving the cells is accompanied by oxygen and the disulfides that have been formed. Immediately leaving the electrolyzer, the anolyte is intensively mixed. The resulting dispersion is settled to give the disulfides an opportunity to separate from the aqueous extractant.

Disulfides are less dense than the aqueous solution. They form a top layer in the settling drum that may be drawn off from time to time. To prevent any dissolved or dispersed disulfides from entering the gasoline, the aqueous solution is given a kerosene wash before it is returned to the extraction operation. The kerosene in the disulfide scrubber is replaced after the disulfide concentration has reached a level that may result in the inadequate removal of disulfides from the alkaline solution. The kerosene is generally replaced when the sulfur concentration is in the neighborhood of 4 per cent.

Electrical Energy Requirements

Reaction a shows that the conversion of 2 gram atoms of mercaptan sulfur to disulfide sulfur requires the removal of 2 electrons. At 100 per cent current efficiency about 12,200 ampere hours are required to convert 32 lb of mercaptan sulfur to disulfide sulfur. Stated another way, at 100 per cent current efficiency 1000 ampere hours will convert about 2.63 lb of mercaptan sulfur to disulfide sulfur. The current efficiency that is obtainable depends upon such factors as the mercaptan sulfur concentration in the electrolyte, the temperature, the current density, and the type of cell.

With aqueous sodium hydroxide as the electrolyte, mercaptan sulfur concentration in the range of 2 to 3 grams per liter of mercaptan sulfur, temperatures about 100 F, current densities of about 80 amperes per sq ft and using an electrolyzer such as has been described, current efficiencies of about 20 per cent have been secured. The type of cell employed and the mercaptan sulfur concentration of the electrolyte are probably the 2 most important variables. When the regenerated solution is circulated at a slightly higher mercaptan sulfur concentration, then considerably higher current efficiencies are obtained.

The voltage drop across each cell is determined by the conductivity of the electrolyte. With 14 per cent caustic soda at 100 F as the electrolyte, the drop in voltage per cell will be about 25 volts. Caustic soda solutions are relatively good conductors but they are surpassed by potassium hydroxide. In instances where power cost is an important factor KOH solutions rather than NaOH as the extractant may be indicated. At most locations the cost for power, which is the principal utility cost, is quite moderate.

Electrolytic Equipment Costs

Table 1 lists the capital investment and power required for the electrolytic conversion of 225 and 500 lb a day of mercaptan sulfur to disulfide sulfur. A current efficiency of 20 per cent and a potential drop of 180 v across the 60 cell electrolyzer were assumed in estimating the ac power needed. The figures take into account the 86 to 90 per cent efficiency with which the rectifier converts alternating current to direct current. Although 180 v was assumed for estimating the voltage drop across the electrolyzer, the rectifier was sized to deliver the necessary current at 240 v. This additional voltage is to take care of unexpected changes in operating conditions. It is presumed that the process is to be employed under normal temperature conditions and that 440 v, 3 phase, ac power is available. The unit figures should be helpful in making a preliminary estimate of the invest-

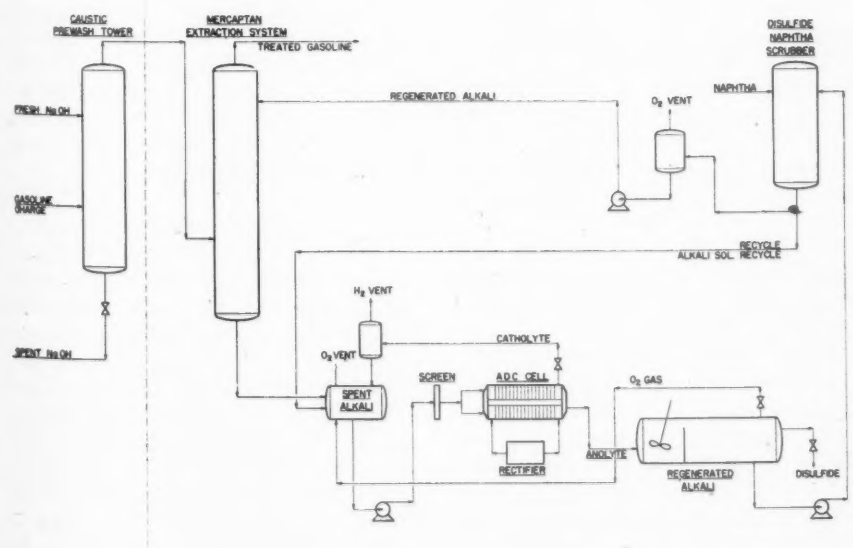

FIG. 3. Simplified flowchart of ADC process.

TABLE 3.

Mercaptan sulfur conversion capacity per day	Estimated ac power required	Investment required in electrolytic equipment per pound of mercaptan sulfur converted per day	Estimated total cost of electrolytic equipment
Pounds	Kilowatts	Dollars	Dollars
225	63	52	11,600
500	136	43	21,400

ment required for electrolytic equipment for most situations that will arise.

Design Considerations

The large number of variables in the ADC process makes it adaptable to various treating problems. In each projected application of the process advantage is taken of the characteristics of the available eletcrolytic equipment and the properties of the aqueous solution that is selected for use. The interrelationships between the more important variables are easily understood. A brief discussion of each of the principal variables will illustrate the devices that can be used to obtain the desired results at minimum costs.

Extraction and Regeneration

With a given gasoline, a specified hydrocarbon-solvent ratio and designated extraction system, the concentration of mercaptan sulfur in the regenerated solvent will determine the mercaptan sulfur concentration of the outgoing gasoline. For this reason it is advantageous to have the incoming solvent contain a minimum of mercaptan sulfur. With a given amount of mercaptan sulfur converted per unit time, the lower the mercaptan sulfur concentration of the regenerated solvent the greater the power required. This economic consideration will generally determine the design mercaptan sulfur concentration of the regenerated solvent.

If this concentration is fixed, then the efficiency of the extraction system and the hydrocarbon-solvent ratio will determine the mercaptan sulfur concentration of the treated stock. The cost of extraction systems varies with the number of transfer stages and capacity. Only after studying the characteristics of a particular stock, utility costs, mercaptan sulfur concentration levels and the like can one arrive at an optimum overall design. Within limits, the more efficient the extraction system, the less efficient need the regeneration system to be to achieve a specified degree of mercaptan removal. While the ADC process has this characteristic in common with other mercaptan removal processes, it has many easily controlled variables that in nearly every instance it is possible to devise an overall design that is economically attractive.

Temperature

Temperature is an important variable in both the extraction and the regeneration step. An increase in temperature decreases the ability of the aqueous solvent to extract mercaptans. Therefore, it is desirable to carry out the extraction operation at the lowest possible temperature. The conductivity of the extractant changes appreciably with temperature, the higher the temperature the greater the conductivity. For this reason it is desirable to carry out the regeneration step at as high a temperature as is convenient.

Although it would be a simple matter to vary the temperature of the aqueous solution as it flows through the process, the disadvantages appear to outweigh the possible gains. As a result the process is usually permitted to seek its own temperature level. This temperature level is determined by the temperature of the stock to be treated and the local environment. Changes in temperature of the extractant show up in the voltage required to keep the stipulated current flowing through the electrolyzer. These changes take place slowly and the control equipment with which the rectifier is normally equipped is adequate to cope with seasonal temperature variations.

By avoiding the heating of the extractant and its subsequent cooling, not only are utilities saved and the investment in equipment avoided but the corrosion difficulties so frequently encountered in treating processes are eliminated. From the long range equipment viewpoint that is regarded as an important advantage of the ADC process.

Circulation Rate

The circulation rate of the aqueous solution through the extraction system and the electrolyzer need not be the same. Frequently, the circulation rate through the electrolyzer is somewhat greater than the rate through the extractor. Ordinarily, there is a small difference between the mercaptan sulfur concentration of the solution flowing into and out of the electrolyzer. If the mercaptan sulfur concentration of the regenerated solution is to be maintained at a low level, then the incoming solution must not be very much higher in concentration. The mercaptans in a stock may be sure that there is an appreciable difference in mercaptan sulfur concentration between the regenerated solution and the spent solution. The mercaptan sulfur concentration of the cell feed is controlled by diluting the spent caustic with regenerated solution. It is generally less expensive to recycle part of the regenerated solution to secure the desired diminution in mercaptan sulfur concentration than to operate on a once-through basis.

It has been found that with the electrolyzers described, there is a relationship between the current efficiency and the flow rate through the unit. Very low circulation rates through the electrolyzer give decreased current efficiencies. For this reason it is necessary to employ certain minimum circulation rates to obtain reasonable current efficiencies. Although pumping costs are a minor item of expense, this discussion of circulation rates has been included to explain certain design features which make for flexibility not only in individual installations but in the application of the process to various stocks.

Oxygen Recycle

Reaction b, resulting in the formation of gaseous oxygen is not necessarily a loss in current efficiency. As long ago as 1888 it was shown[6] that oxygen or air would oxidize sodium thioethylate. Lachman in 1931[7] proved that mercaptans in the presence of sodium hydroxide solutions can be oxidized by air. He mentioned the difficulty of securing consistent results because the rate of the reaction is markedly influenced by traces of either catalysts or inhibitors. In 1941 Xan et al.[8] showed that a temperature of about 85 F sodium hydroxide solutions containing dissolved mercaptans absorb oxygen at an appreciable rate when the solutions are intensively agitated in a gaseous oxygen atmosphere maintained at a pressure of one atmosphere. The absorbed oxygen converts the mercaptans to disulfides.

The ADC process takes advantage of the ability of dissolved oxygen to oxidize mercaptans to disulfides as a step supplementary to the conversion which takes place in the cell. This is accomplished by thoroughly mixing the gaseous oxygen and solution flowing from the anolyte header. The reaction rate is sufficienly high to more than justify the installation of the mixing equipment. In one installation this reaction accounts for about 20 per cent of the conversion which takes place.

As a further means of using the oxygen, new designs contemplate mixing the oxygen gas not absorbed by the anolyte with the spent caustic prior to its entry into the electrolyzer. This device is expected to further increase the utilization of the oxygen. To the extent that additional oxygen utilization is obtained, the overall current efficiency will be improved.

Pretreatment

Many stocks containing mercaptans contain small quantities of other acidic substances, namely, hydrogen sulfide and phenolic compounds. These substances are both more acidic than mercaptans so that when they are present, they will be extracted by the aqueous phase in the extraction step. H_2S is such a strong acid that when present in even minute concentration, it will be extracted by solutions as alkaline as sodium sulfide solutions. Sulfide in the solution fed to electrolyzer has a very

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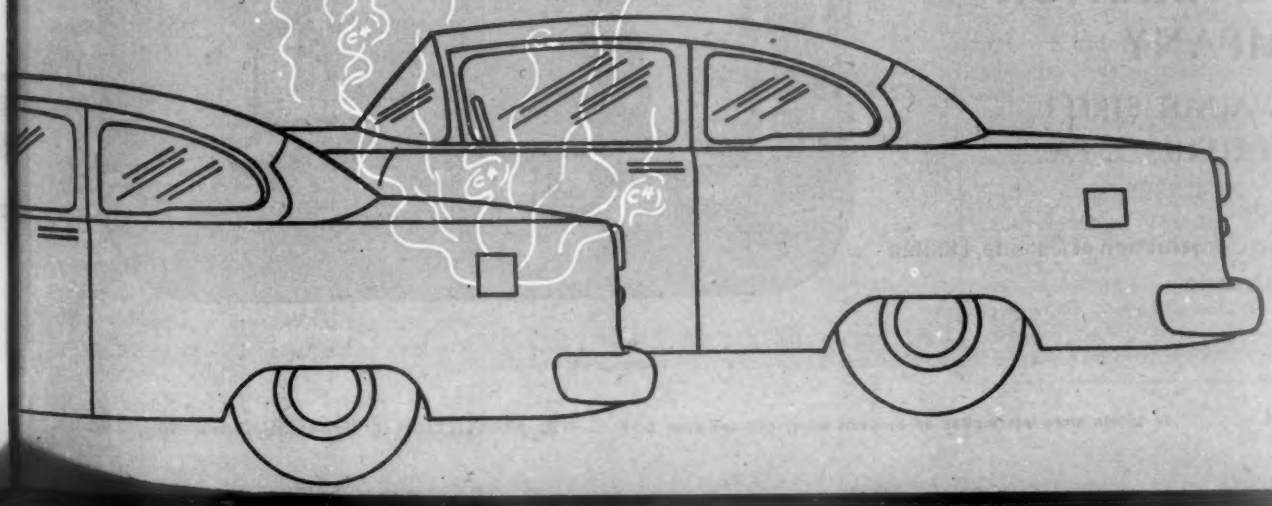

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By the banks of the Wabash River at Robinson, Illinois, this new 8,330 barrel-per-day Houdriformer of the Ohio Oil Company is on stream, producing a high yield of superior quality gasoline from naphtha charge stocks. The new catalytic reforming unit is equipped with three catalytic reactors, a guard reactor and a three-stage heater.

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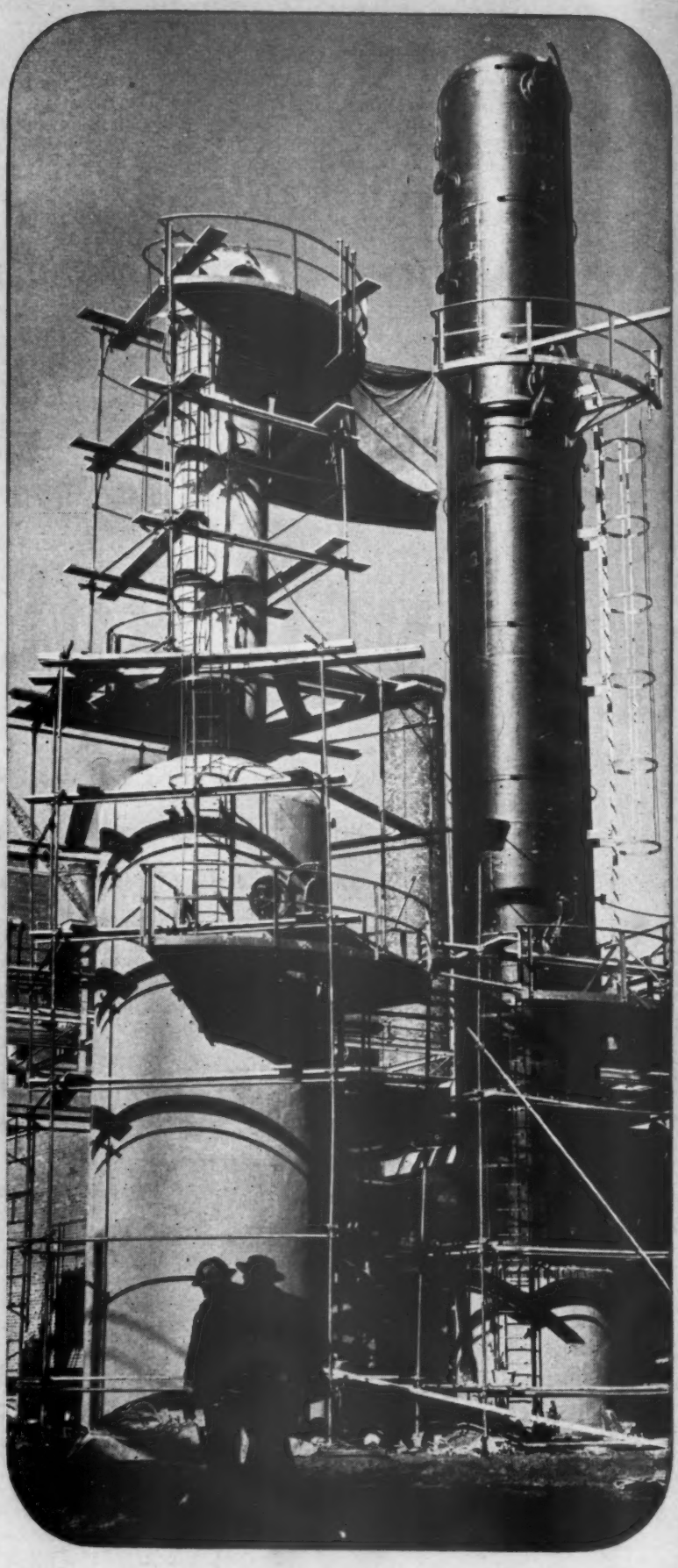

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detrimental effect. It is more readily oxidized than mercaptans. The electrolytic oxidation of sulfide results initially in the formation of thiosulfate and eventually in the formation of sulfate. Thus, not only is the alkalinity of the extractant reduced but the conversion capacity of the electrolyzer is diminished. To avoid this condition the feed to the treating process should be sulfide free.

Acid oils in the feed will also be extracted by the aqueous alkaline solution. This has the effect of decreasing the free alkali content of the extractant and thereby diminished its conductivity. The change in conductivity takes place gradually. Although the voltage must be raised to keep the current at the desired level, the current efficiency is not affected. As the free alkali content of the extractant declines, the conductivity gradually decreases to the point where an excessive voltage is required. In addition, the selective solvent power of the solution is diminished. These detrimental effects of an excessive accumulation of acid oils require that means be available for controlling the acid oil content of the circulating solution. One method of doing this is to use a two stage prewash system. Another method employs a single stage caustic prewash which is described in more detail below. Acid oils in the ADC process must be controlled as they must be controlled in all other mercaptan extraction processes.

Hydrocarbon Feed

Straight run, thermally cracked and catalytically cracked stocks are being handled on a routine basis. The degree of mercaptan removal achieved varies with the extraction systems employed, the concentration and type of mercaptans in the feed, and the conversion capacity of the electrolytic equipment. There is no evidence indicating that one type of mercaptan is more readily converted to disulfides than another.

If an acid oil-containing stock is given a single stage caustic prewash inevitably some of the acid oil will not be removed in the prewash step. This acid oil will then be picked up by the alkaline solution in the regenerative cycle. In time, this causes difficulty of one sort or another. This situation can be controlled by using the regenerative cycle as the second stage of a two stage caustic prewash operation. After the caustic in the first stage is spent, it is replaced by solution from the regenerative cycle, and make-up caustic is added to the regenerative cycle. Such a procedure can be carried out at the expense of a somewhat higher average drop in voltage. By operating in this way, the extraction equipment of the regenerative system has a dual role which aids in keeping down the total overall investment.

Maintenance

The principal item of maintenance is the periodic replacement of the diaphragms. There is little other maintenance as there is no need for heaters, coolers, condensers, and the like. The electrolyzer is constructed of steel and cast iron which at the temperatures employed withstand the caustic solution indefinitely. The rectifiers employed in the process rarely require any attention.

Commercial Installations

At Refinery A where a thermally cracked stock was treated, replacement of the steam regeneration process by the ADC process resulted in an annual savings in excess of $40,000 in utilities and some savings in tetraethyl lead. Savings which have not been quantitatively evaluated resulted from decreased maintenance and inhibitor costs. The capital investment required for the electrolytic equipment and auxiliary facilities was repaid within a year.

After exploring alternative treating processes, the ADC process was selected for use on straight run naphtha at Refinery B. This is a large foreign refinery that previously had no facilities for mercaptan removal. The incentive for making the capital investment was the expectation of securing increased lead susceptibility of the base stock. From the very beginning, the improvement in lead response amply justified the installation.

The ADC process installation at Leonard Refineries, Inc. replaced the steam regeneration process in treating TCC gasoline. Four dollars and fifty cents worth of electricity has replaced $16 worth of steam per 1000 bbl of gasoline treated. Since the installation of the ADC process, 70 per cent of the mercaptans in the TCC gasoline have been extracted compared with an extraction of 50 per cent when the steam regeneration process was employed.

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★ ★ ★

PLANT AIDS

24 Hour Green Gas Graph†

R. E. SCURLOCK*

The life of a natural gasoline plant depends upon the gas that it receives from the field to be processed. The rate of flow of gas to the plants is one of the most important factors. If too much gas is received at one time, it overloads the engines and might shut the plant down. If not enough gas is coming in, it causes the engines to run idle and forces the plants to buy residue gas to operate on and also maintain residue gas pressure to the field. If the flow schedule man could arrange the lease flows so as to have the same amount of gas coming into the plant each hour of the day, he would be a happy boy, but he is not happy. After computing the daily charts each morning, the gas figures from all of the lines can be taken and make the gas graph to show just how much gas was coming into the plant each hour. The graph is numbered horizontal for 24 hours and vertical from 100 MCF to 1000 MCF. By plotting the gas flow each hour on the graph, it gives a clear picture of the gas received and the flow-schedule man can arrange some of the flows to fill in where the gas is needed most in order to get an even flow throughout the 24 hours.

*Warren Petroleum Corporation, Gladewater, Texas.

†Class C, third prize, NGAA Kinks Contest.

Belt Fasteners—Not Belt Hooks

W. F. Schaphorst, M.E.

Are all metallic belt fasteners "Belt Hooks"? No. It is hard to understand why so many belt users and even belt experts apply the name "belt hook" to such belt fasteners as are now commonly used simply because those fasteners are made of metal.

"Belt hooks" are used for fastening round leather belting only, and for nothing else. They are shaped much like a tall letter "C" the curved ends preventing the round belt from slipping out after it is in position.

The "C" type of hook is the only real belt hook in leatherbeltdom. The belt hook was in existence before other types of modern metallic fasteners came into use and for that reason, no doubt, the term is misapplied to all belt fasteners made of metal.

They are "belt fasteners."

CORRECTION

In the article, "Chemical Flocculation for Refinery Waste," by Roy F. Weston and R. G. Merman, in the Refining and Petrochemical Edition for October, 1954, page C-35, first paragraph, the expression, "10 mgd**" means 10,000,000 gal per day instead of 10,000 gal per day.

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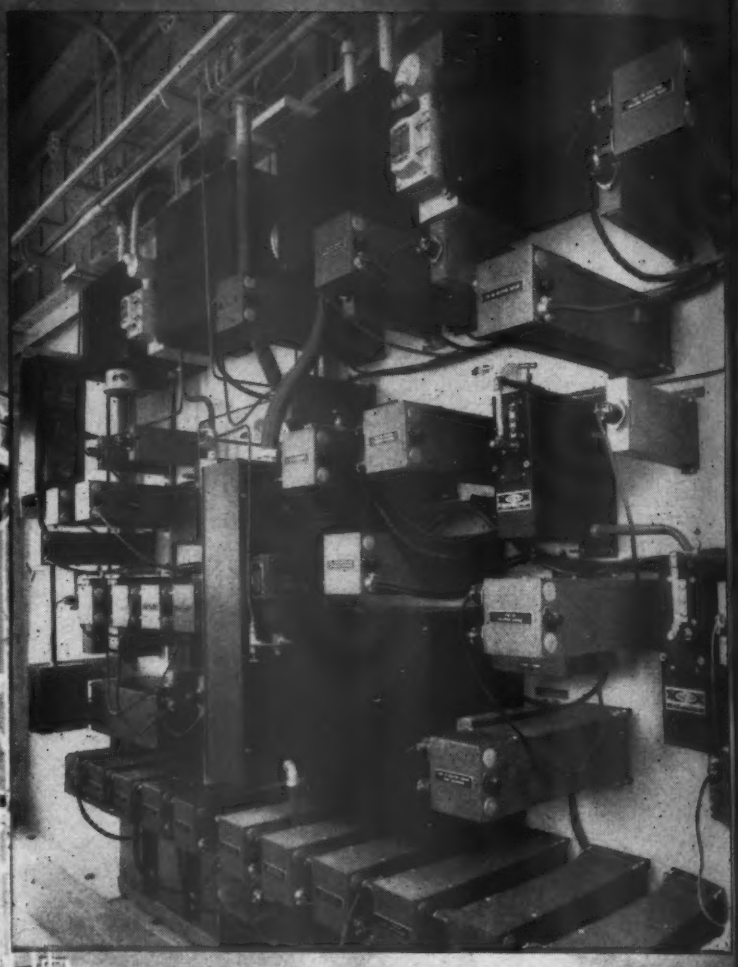

This view shows the back of the graphic control panel and of the electronic instruments for the UOP Platforming unit at the refinery of Rock Island Refining Corporation at Indianapolis, Ind. This Platformer is the first complete refinery unit in the United States to be controlled by electronic equipment.

Rock Island Refining Corp. Has First Complete Refinery Unit Controlled By Electronics

By L. E. Winkler
President
Rock Island Refining Corp., Indianapolis, Ind.

PROGRESSIVE thinking and action are vital to our refining operations. Since Rock Island Refining Corporation was organized in 1940, we have constantly sought to maintain our position as one of the most modern refineries in the world, dedicated to staying in the forefront of the petroleum refining industry as it produces higher quality products.

L. E. Winkler

Rock Island was the first refinery in the world to install a graphic control panel, a device which since has revolutionized the control of refinery processes. It was also one of the first refineries anywhere to build a UOP "stacked" Fluid Catalytic Cracking unit.

Now Rock Island has scored another "first"—a complete refinery unit which is instrumented by electronics.

The new type of instruments are controlling our 2,400 barrel-per-stream day UOP Platforming unit, which went on stream recently to produce motor fuel blending component. Although the Platformer has been running only a short time, the electronics equipment already has paid dividends through a smoother startup and easier handling.

Our decision to install electronic controls was based on economic factors as well as our desire to keep ahead of the industry in modern refining techniques. We took a long-range look at the potentials of this new type of equipment and ascertained that:

(1) It would increase the reliability of the Platformer's operation in cold weather by eliminating the possibility of freezing up of instrument transmission lines.

(2) It would do away with racks for the pneumatic tubing from the graphic panel to the battery area, thus reducing initial installation costs and problems connected with startup and maintenance operations.

(3) It would result in better control because of the increased sensitivity of electrical impulses.

Controls Work Perfectly

The electronic controls worked perfectly from the very beginning. On the day selected for the startup of the Platformer, oil was put into the unit at 9:30 a.m., and in less than three hours the unit was completely "lined out"—operating smoothly at the desired conditions. In less than two weeks, the unit had fully proved itself and had come to be considered a part of our routine refinery operations. Universal Oil Products Company designed, engineered and licensed the Platformer. UOP's instrument department engineered the installation of the electronic controls.

In our instrumentation, transmitters located in the battery area of the Platformer measure temperatures, pressures and flow and convert them to electrical signals. These go to recorders located on the graphic panel and to controllers, also located on the panel.

The controller compares the signals with a signal from the set point mechanism on the recorder that has been set previously by an operator. The controller sends out a current signal to the control valve, causing it to assume a given position. In the event the transmitter signal does not match the set point signal exactly, the controller modifies the current signal to the valve, located in the battery area. At the valve, the current signal is converted to a pneumatic pressure corresponding to the current signal in order to supply the power necessary to position the valve. This causes the valve to either open slightly or close slightly in order to bring the transmitter signal back into line with the set point signal.

Electronic Controls Act Swiftly

We have found that the electronic controls give almost instantaneous response when there are variations in temperature, pressure or flow through the Platforming unit. In addition, there are few moving parts in the equipment, thus reducing maintenance and wear. There is also complete interchangeability of parts, making it as easy to change parts as it is to change a light bulb.

We at Rock Island are proud to be the first refinery in the United States to install complete electronic controls to operate a major processing unit, and we believe sincerely that this instrumentation will go far toward helping us to consistently make better petroleum products from the crude oil that we process.

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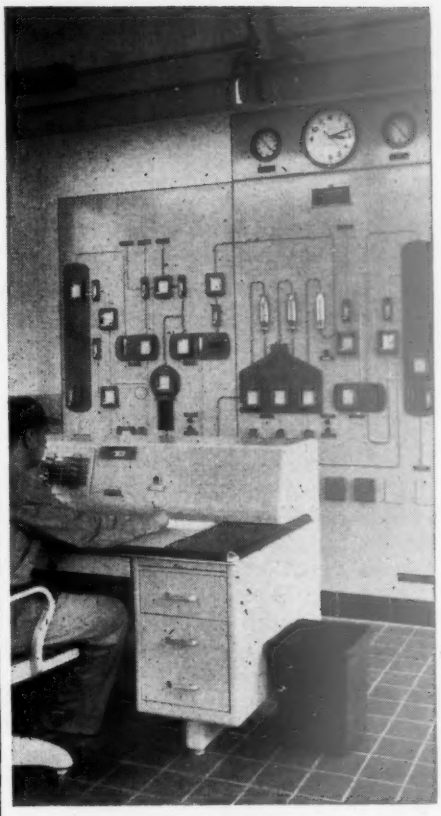

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Famous mahogany ledge has potential of 100 billion barrels

HYDROGENATION IMPROVES SHALE OIL REFINABILITY

ARCH L. FOSTER*

RECOVERY of shale oil from the famous mahogany ledge of the Green River shale formation in Colorado, Utah, and Wyoming, will yield 100 billion of barrels of crude shale oil, as much as our whole world-wide known petroleum reserves, Clyde Berg of Union Oil Company of California told the members of the Institute of Chemical Engineers assembled in Colorado in its September meeting. This ledge runs some 30 gal of oil per ton of raw shale, under present recovery methods, is the most productive of the oil shales in the entire region. The Picance Creek Basin covers 1000 sq miles, contains potentially 350 billion barrels of oil and averages 500 ft thickness. The mahogany ledge is only 100 ft thick, but shows higher per-ton yields. Thus, in this one area is concentrated 3 times as much potential shale oil as our entire known world petroleum reserves. The last 5 years have seen great advances in recovering and refining this oil, Berg pointed out.

The U. S. Bureau of Mines has developed important methods for mining shale in large quantities by using large-scale heavy machinery equipment, to bring the costs down to a hitherto unbelievably low level. On the basis of these developments, and of Union Oil's research in refining shale oil, it has been determined that:

1. Total cost of refining shale to gasoline, for example, is higher than for gasoline from petroleum, by the difference between 12-12.6 cents per gal for petroleum motor fuel, to 14.7 cents pet gal as the NPC's 1951 estimate for multiplant shale oil refining.
2. Shale oil represents our most attractive source of synthetic fuels, "and warrants continued attention by the petroleum industry."

On the basis that a single modern mine can produce 20,000 tons per day of oil shale, Berg makes up an estimate of the refining routines starting with the 50-ton per day Union retort to recover 13,125 bbl per day of shale oil from 20,000 tons of shale. The plant to retort this shale would contain 20 retorts of 1000 tons daily capacity each.

Shale oil so produced has a typical boiling range from 400 Initial to near 900 F, or cracking temperature, 2.01 per cent nitrogen and 0.77 per cent sulfur. Coking the crude shale oil will yield about 80 per cent of 700 F endpoint distillate, having about the same amount of sulfur but only about 1.5 per cent nitrogen. Hydrogen for other refining (hydrogenation) is obtained by reforming the methane-ethane, produced in the coking step, with steam. Further refining must remove the nitrogen, sulfur, and oxygen, and saturate the olefinic and other reactive constituents.

The oil may be treated with the cobalt-molybdate catalyst or by Unifining, which will form hydrogen sulfide, ammonia and water of the impurities; also the olefins will be reduced by hydrogen addition but aromatics are not changed appreciably.

Coking and hydrogenating 100,000 bbl of crude shale oil will yield 85,000 bbl of jet and diesel fuels along with nearly 2400 tons of coke. To make gasoline instead of so much jet and diesel fuel, a total of 81,520 bbl of gasoline (50,000), diesel fuel (26,000), LPG, (3600), and heavy fuel (1200) can be made. One big problem in the vicinity of the oil shale area is that of adequate supplies of water needed for refining.

By Hyperforming a mixture of low-grade paraffinic petroleum naphtha and shale oil naphtha an exchange of hydrogen takes place that eliminates need for outside hydrogen. It is noted that estimates of costs have come down from the 1948 estimates of about 25 cents per gallon, to 19-22.5 cents in 1949, to 14.7 cents in 1951. These reductions show the improvements in processing made during that period.

EXCLUSIVE

Coker Distillate

C. K. Viland of Tide Water Associated Oil Company has found that catalytic cracking of coker distillates from raw shale oils shows substantially lower gasoline yields than those obtained similarly from a light East Texas gas oil. The diesel fuel range charge from this coker distillate gives fair product distribution in cat cracking, but the nitrogen, sulfur, and metals content indicate a rapid catalyst poisoning. By hydrogenating the distillate these poisons are removed; severe hydrogenation tends to make the distillate more refractory for cat cracking, lessening yields of gasoline.

Rehydrogenation of a once-hydrogenated shale oil shows that:

1. The first hydrogenation removes all these impurities and is not improved by the second hydrogenation.
1. Hydrocracking that occurred in the second step probably produced a more refractory stock.

The rehydrogenated oil showed 68 per cent paraffins and naphthenes, 32 per cent aromatics and no olefins, essentially the composition of the once-hydrogenated oil, which was 70-30 paraffins-naphthenes, and aromatics. Catalyst used was a natural catalyst on the once-hydrogenated charge and the absence of the coke-promoting nitrogen in this stock helped to improve the results, which showed 31.6 volume per cent of gasoline and a 9.3 per cent fraction. Same operation on the rehydrogenated oil gave 23 per cent gasoline and 12.8 per cent butanes, a lower yield than on the once-through charge.

From the raw coker distillate the gasoline yield (to the same 5 per cent carbon deposit stage on the catalyst) was 27.3 volume per cent as compared to 35 per cent from vacuum distillate from California crude, and 41 per cent for Arabian heavy gas oil. More of the sulfur stays in the shale oil gasoline than stays in the Arabian crude gasoline, which means a greater treating

*Editor, Refining, Petrochemical and Gas Processing.

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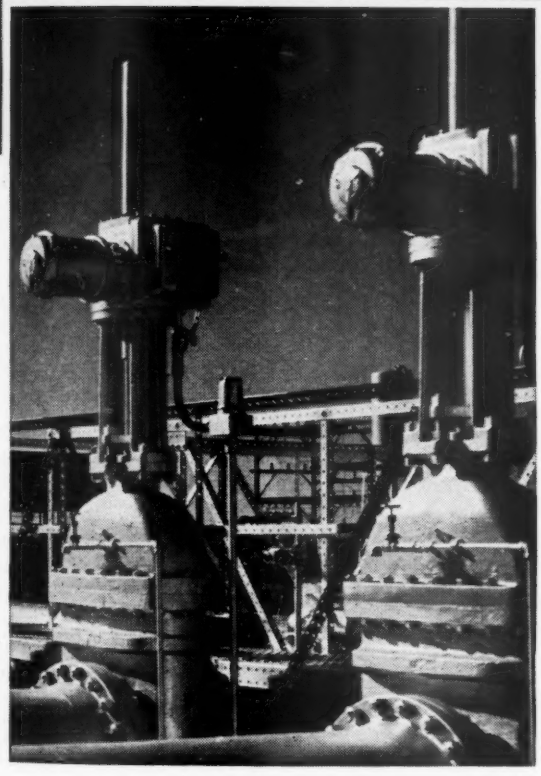

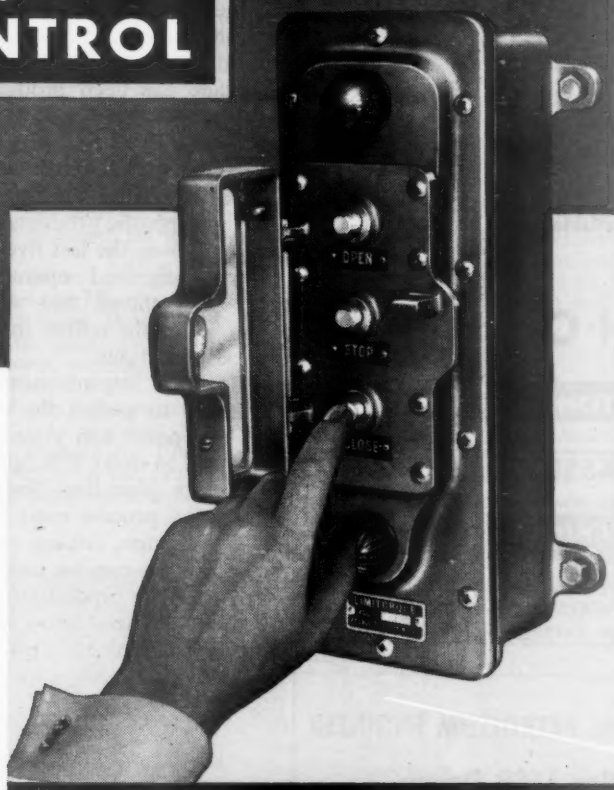

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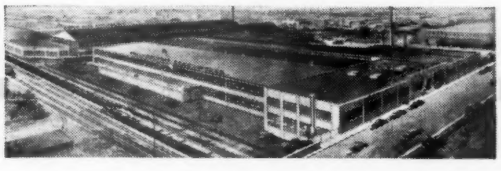

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problem for the raw gasoline. Octane rating of the catalytic gasoline from raw coker distillate diesel fuel cut was slightly lower than from the 2 petroleum fractions mentioned, 74.9 as compared to 79.2 and 79.7, respectively. From the cat cracked hydrogenated diesel fuel fraction octane rating was 80.6; from rehydrogenated charge from the same fraction, 80.1, a slight improvement over the petroleum-derived gasoline.

Marketable Products

Thermal cracking followed by sulfuric acid treatment enables the refiner to make usable, marketable gasoline and residual fuel oil from shale oil, Boyd Morris and R. J. Cameron of the Bureau of Mines at its Rifle, Colorado, laboratory reported to the chemical engineers. Gasoline of "regular" grade has been produced in quantity and has been tested on the road by Bureau cars and trucks for a considerable time. Usable diesel fuel, also heavy fuel oil, coke and pitch, and certain asphaltic products have been made also. Over the last five-year period engineering and operating data have been gathered that will make it possible for the refiner to fit shale oil into his operations.

Three improvements must be effected to permit the use of shale oil. Pour point and viscosity must be reduced to make it feasible to handle the oil via pipe line. Some sort of conversion process must be used—as hydrogenation, coking, etc.—to get fractions that can be used for diesel fuel or gasoline production. These products when obtained must be treated to remove combined nitrogen, sulfur, and oxygen to improve stability before they can be marketed.

Sulfur in shale oil is not specially high in percentage, and is found more as thiopene and its homologues. Nitrogen content is higher than even California crude petroleums and must be removed before proper results in cat cracking can be obtained.

Cracking the crude shale oil in a single-coil Dubbs unit with recycle 930 F and 157 psig gave 43 vol per cent naphtha and about the same residuum, the residuum being 4.6 API gravity, the naphtha 52.4 API with about the same sulfur content as the residuum but much lower in nitrogen (1.06 per cent), than either the charge (2.13) or the residuum (3.24). The naphtha showed 50 per cent olefins, 19 per cent aromatics, 31 per cent paraffins-naphthenes, and a research method octane number of 75.8.

Cracking shale gas oils shows lower gasoline yields than is expectable from petroleum gas oils. Conventional thermal reforming of cracked shale oil napthas is not an attractive method for upgrading these primary products, the authors decided from the data obtained. Yield and octane number increases are about the same as for petroleum reforming, but after treating the shale naphtha reformate shows octane number barely adequate for non-premium motor fuels. Suspensoid catalytic cracking of shale oil seems to have some merit, but has not been investigated exhaustively.

Chemical treating must remove especially the nitrogen compounds, said to be responsible mainly for the instability of shale distillate. Sulfur, found as thiophenes, etc., has little odor and little effect on TEL susceptiblity but is above standard limits for marketed products. At the same time, acid treating that removes nitrogen also shows that these nitrogen compounds are high in octan number, and treating lowers the gasoline octane rating severely. The finished, treated motor fuels have been tested satisfactorily in automotive equipment at the Rifle station for several years, natural gasoline being blended to give required volatility properties.

Diesel fuels from shale oil must be treated to remove the nitrogen and sulfur to reduce the odorous and highly unstable constituents. Treating losses are high, up to 25 per cent losses being obtained.

Better Distillates

With a cobalt molybdate catalyst a 1200 F retort oil was hydrogenated destructively to a 90 per cent yield of stabilized gasoline of 90 leaded octane rating, it was reported by R. L. Crecelius and several collaborators in the Bureau of Mines laboratory at Laramie, Wyoming. A crude shale oil from a gas-combustion retort was hydrogenated in a recycle system to give a 700 F endpoint stock low in nitrogen and sulfur, and this stock was cracked catalytically to a 90 octane number leaded gasoline with yields comparable to those from petroleum fractions.

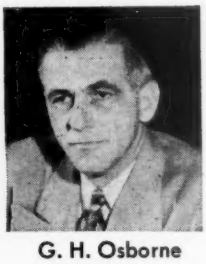
Extracting oil shale kerogen with solvents in not promising, but the kerogen can be degraded thermally in a solvent to give a product more nearly the original kerogen that the oil from dry destructive distillation degrading the kerogen in tetralin solvent at 392—572 F was found to increase with higher temperature of extraction and decreasing organic content of the shale, W. R. Thompson and C. H. Prien, Denver Research Institute have found. Enthalpy changes for the solution process was found to increase also with both extraction temperatures and organic content of the shale tested.

* * *

REFINING AND PETROCHEMICAL PERSONALS

Robert V. Jelinek has resigned from Columbia University to accept an appointment as Assistant Professor of Chemical Engineering at Syracuse University.

H. V. Smith



G. H. Osborne

Howard V. Smith has been named vice president in charge of refining for Kendall Refining Company. Smith joined the Kendall organization as refinery manager in April of 1943. In 1944 he was elected to the board of directors. A graduate of the University of Kansas, Smith was assistant superintendent of refining for Skelly Oil Company at El Dorado, Kansas.

G. Harold Osborne has been named vice president in charge of marketing for Kendall Refining Company. A graduate of Pennsylvania State University. Osborne joined Kendall in 1933 as a refinery employee. He was elected to the board of directors in January of 1951. He was formerly general manager of sales.

G. D. Butterworth has been appointed head engineer, project engineering, in Standard Oil Company's general engineering department, recently established at Whiting, Indiana. Butterworth, a graduate in chemical engineering from the University of Oklahoma, joined Standard in 1944 as a chemist at the Sugar Creek, Missouri, refinery. He was transferred to Standard's Wood River, Illinois refinery in 1953. For the past year he has been assistant superintendent of the light oils division there.

A. T. Milbrook, utilities engineering division; **W. K. Brown,** construction and estimating; **H. M. Romig,** process engineering, and **W. R. Burrows,** special services have been named chief engineers for their respective divisions in Standard's new general engineering department. **Benjamin Franklin,** assistant chief engineer for the manufacturing department, was appointed chief engineer for the department's contracts division. **Sloan Haworth,** assistant chief engineer of the Wood River, Illinois refinery, was named chief engineer of the coordinating and administrative division.

Head engineers from the Whiting refinery named to posts in the new department were **F. B. Brueckmann,** consulting engineer; **F. A. Upson,** assistant chief engineer of process engineering; **J. C. Howard,** assistant chief engineer of the electrical engineering department, and **K. C. Lowe,** assistant chief engineer of the construction department. **R. R. Penman,** head engineer for manufacturing engineering, was named assistant chief engineer, special services. **K. L. Carter,** assistant superintendent of the utilities division at Wood River, was appointed assistant chief engineer of the still and hydraulic department. **C. E. Dyckman,** former assistant chief engineer of the Whiting refinery's estimating department, holds the same title in the general engineering department.

Transferred from the Whiting refinery as head engineers in the general engineering department were **W. W. Bond** and **J. W. Cooper.** Whiting refinery personnel named as assistant head engineers of the new department were **C. L. Ranck, G. A. Erickson, E. C. Hamman, Jr., G. A. Hankins, R. V. Nutt, C. A. Olson, A. C. Sampson, D. F. Sands,** and **C. L. Swift. H. G. Kabbes,** head engineer at Standard's Neodesha, Kansas refinery, also was named an assistant head engineer in the new department.

H. R. Wall, superintendent of Continental Oil Company's Ponca City, Oklahoma refinery, has been promoted to regional manager of manufacturing for Continental's southern and southwestern regions. Wall succeeds **J. H. Olehy,** who has been transferred. **L. D. Grubb,** assistant superintendent at the Ponca City refinery, has been promoted to succeed Wall. **C. B. Round,** formerly assistant to the vice president in charge of manufacturing, will succeed Grubb.

J. M. Jones, superintendent of the Continental refinery at Lake Charles, Louisiana, has been promoted to the newly created position of manager at Lake Charles. **W. F. Brown,** superintendent of the catalytic cracking division in Conoco's Ponca City refinery, was promoted to superintendent at Lake Charles. **M. L. Cobb,** director of training for Conoco's manufacturing department, was promoted to an assistant superintendent of the Ponca City plant.

C. R. Draughon has been awarded a certificate of appreciation by the Petroleum Division of American Society of Mechanical Engineers. Draughon is head of the maintenance and construction department of Esso Standard Oil Company's Baton Rouge, Louisiana refinery.

M. W. Nicholas

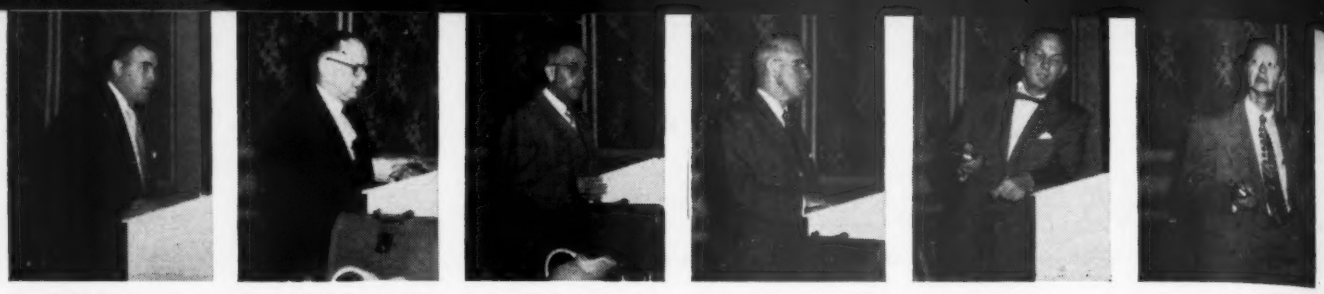
R. W. S. Musgrave

M. W. Nicholas, formerly assistant to the manager of refining for Ohio Oil Company, has been appointed refining staff manager. **R. W. S. Musgrave** has advanced from chief refining engineer to refining engineering manager.

Nicholas joined Ohio in 1928 as a clerk at the Robinson, Illinois refinery. Transferred to the general office at Findlay, Ohio in 1935, he advanced later to head of the refining and marketing accounting department. In 1942 he returned to the refinery as statistical advisor and 5 years later was appointed assistant to the manager of refining. He returned to Findlay in that capacity in 1947.

Musgrave has been an engineer in Ohio Oil's refining department for more than 26 years. Beginning at the Robinson, Illinois refinery, he served later at Fort Worth, Texas, and Lovell, Wyoming. He was named chief mechanical engineer at Robinson in 1943 and chief refining engineer in 1946. He has been located at the Findlay office since June, 1954.

Uranium, petrochemicals, heat exchange, costs, market research, and new products were some of the subjects discussed by the speakers who addressed the Oklahoma Section American Institute of Chemical Engineers in Tulsa, Oklahoma, on October 2nd. Speakers were: Seated, Dr. Barnett F. Dodge, Yale University; Dr. M. B. Goren, Kerr-McGee, and Dr. C. A. Stokes, Godfrey L. Cabot, Inc. Standing, John F. Gilmore, Blaw-Knox; P. L. Weller, Spencer Chemical Company; Dan M. Krausse, Cosden; E. D. Anderson, Western Supply, and A. J. DeCillis, Continental.



R. B. McClelland, Oil Insurance Association, "Refinery Fire Insurance Rating." F. E. Mathews, Standard Oil Company (Indiana) president, Industrial Relations Session. Wilson H. Tanner, Continental Oil Company, "Communications in the Rocky Mountain Region." Lee Laird, Standard Oil Company (California), "Fringe Benefits." R. E. Wood, Esso Standard Oil Company, "Fluid Coking Yield Studies." K. E. Stanfield, U. S. Bureau of Mines, "Asphalts from Rocky Mountain Crudes."

WPRA Regional Meeting:

P 700.

Casper Meeting Covers Men, Methods, and Mutual Problems

ARCH L. FOSTER*

FROM the tremendous Rocky Mountain Oil Empire refiners gathered at Casper, Wyoming, September 23-24, to exchange experiences and ideas on their mutual problems, under the auspices of the Western Petroleum Refiners Association and Paul D. Williams, technologist for the association. Among subjects taken up at the two-day meeting were methods of coking heavy residual oils to show higher yields and better financial returns from mountain crudes; treating refined products to eliminate deleterious impurities such as sulfur and reduce these treating costs to enable the refiner to carry on more profitable operations on high-sulfur crudes; making suitable asphalt for road and other applications from mountain crudes and methods for promoting the "human" side of relations of employee and employer.

As disposal of heavy crude residues has become an overshadowing problem, due in good measure to a strong reduction in the railroad locomotive consumption of heavy fuel oils, the application of the process known as fluid coking has attained new importance. Yields of 11 to 28 per cent coke are obtained from different crudes; 19 to 21 per cent of naphtha up to 430 endpoint, and about 50 to 70 per cent of heavier-than-naphtha liquids are obtained, along with 10-12 per cent C_3's and C_4's. As high as 48 per cent coke is made from visbreaker tars, with lower proportions of naphtha and heavier. Twice as much gas oil is produced by pilot plant fluid coking as by commercial delayed coking, however, and correspondingly, delayed coking gives twice as much coke as fluid operation; reported by F. B. Johnson and R. E. Wood of Esso Laboratories.

Rocky Mountain Crudes lend themselves in general to production of asphalts of excellent characteristics, K. E. Stanfield, Bureau of Mines chemist, reported. Also, shale oil obtained by different methods of retorting shows certain prospects for yielding suitable asphalts and some investigation of the methods and possibilities of asphalt production from shale oil have been carried out. Asphalt studies at the Laramie, Wyoming, Experiment Station were discontinued June 30 for lack of funds. (The Stanfield paper will be published in full, soon.—Ed.)

Electrical methods for the regeneration of spent caustic solutions employed in treating refinery products, such as gasoline have been perfected, Dr. C. W. Rippie, nationally known authority on refinery chemical treating methods, reported. His discussion (to be published in full in an early issue), covered in detail the relative advantages of electrical as compared to other regeneration methods.

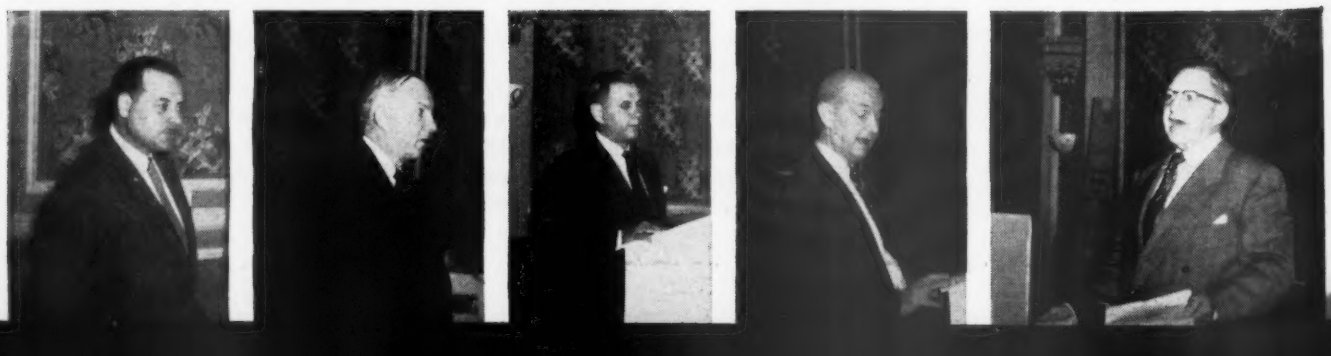
"Fringe benefits" for employees of the oil industry are the highest in the entire world, Lee Laird, benefits division manager for Standard Oil of California reported. Costs of these extra benefits average $1178 per oil company employee. One petroleum company reports spending more than $2700 per year for benefits other than salaries and wages. The lowest rates are for the textile and apparel industry, $451 per employee per year. Petroleum companies also pay the highest rates of all industry, 24:5 per cent of the total company payrolls, some companies paying as high as 40 per cent. The total cost of each hour's work is about one-third more than the stated hourly wage rate, for Laird's company.

Employees need to feel that they are "on the team," says D. C. Houston, director of industrial relations for Kennecott Copper Corporation. Consideration of the human relations phases of employee affairs is paramount to the successful handling of employees, Houston indicated. Praise for good work, "handed out" for all to know, has much to do with high employee morale.

*Editor, Refining and Petrochemical Edition.

Paul D. Williams has been appointed acting secretary-treasurer of the Western Petroleum Refiners Association, to succeed John C. Day, former executive secretary-treasurer who died October 5. Williams has been technical director for WPRA for the past ten years.

F. L. Mace, Continental Oil Company, co-author, "Operations Information." C. W. Rippie, Electric Process Company, "Electric Mercaptan Process and H_2S Salt Process Reduce Stream Pollution." C. O. Anderson, "Rock Island's Electronic Controlled Platforming Unit." C. R. Holton, Ethyl Corporation, "How One Company Benefitted from Employee Opinion Survey." D. C. Houston, Kennecott Copper Corporation, "Pattern for Personnel Practice." Papers were illustrated profusely and were adequate for complete information.



REFINERY PLANTS SCHEDULED FOR COMPLETION

Ashland O. and R. Company. A new Houdriformer unit at Ashland's No. 2 plant at Catlettsburg refinery will be started in October. Unit will be of 8500 bbl per day capacity for the pretreater and 6000 bbl per day of reforming capacity. Engineering and construction is in the hands of Catalytic Construction Company, completion due in mid-1955. Unit will produce high octane number blending gasoline and naphtha specialties.

★ ★ ★

Chicago-Champlin Refining Company. Contract has been signed for a 9000 bbl per day charge Model B Orthoflow fluid catalytic cracking unit at the Enid, Oklahoma, Champlin refinery between Chicago Corporation and M. W. Kellogg Company. Unit is to be completed in "11½" months, it is anounced. A 5000 bbl per day Platformer unit will be built at the same refinery by Southwestern Engineering Company, to be completed in 7 months. Chicago-Champlin president Earl Baldridge, says company will spend $4,000,000 in modernizing and expanding the refinery.

★ ★ ★

Iraq Lube Plant. A new 25,000 tons per year lubricating oil plant is planned for Iraq's new refinery to be completed in mid-1955. Bids for its erection will be asked soon from British engineering firms. It is to be built at the Government's refinery going up at Dora, near Baghdad.

Albatross S.A.BpRP. A 3600 bbl per day catalytic cracker unit has gone on stream at Antwerp, Belgium. Plant will make cat cracked motor fuel for Belgian-owned cars. Belgium has the greatest number of American-made cars of any European country. Refinery was damaged badly during World War II, and remained inactive until war's end. It now is rated at 10,000 bbl per day crude capacity, operating on Persian Gulf crude. Houdry Process Corporation and Head Wrightson of London handled engineering and procurements. Petro-Carbon Ltd. of Manchester, England is consultant to the refinery company.

★ ★ ★

Commercial Solvents Corporation. A nitroparaffin plant is to be built at Sterlington, Louisiana, alongside company's ammonia, nitric acid, and methanol units. Plant is to cost $5,000,000. Work on it has begun, and it will go on stream in August, 1955. Ford, Bacon and Davis have handled this construction, and will handle also expansion of nitroparaffin capacity at Peoria, Illinois.

★ ★ ★

Atlantic Refining Company. Atlantic's new Catformer unit at Atreco, Texas refinery, has been completed and is on stream. Built by H. K. Ferguson Company, the unit is processing low-grade naphtha from the refinery to make high octane number gasoline.

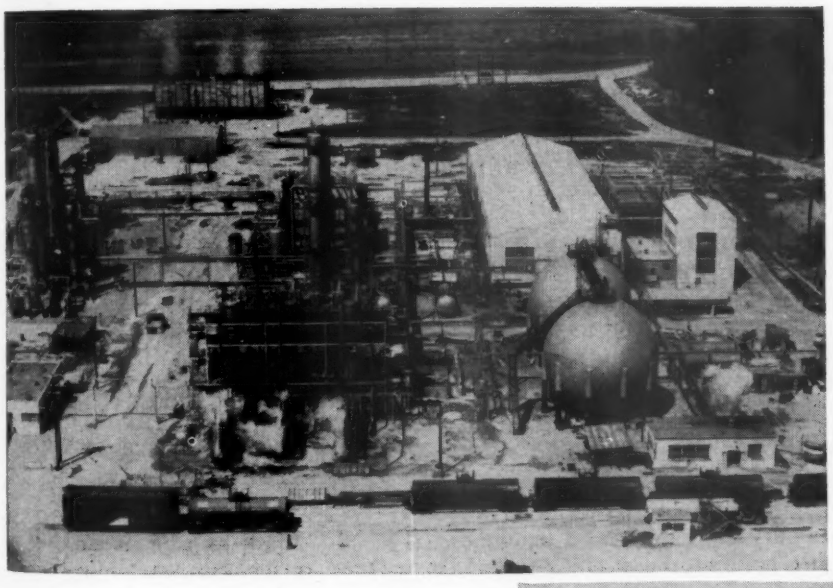
Consumer's Cooperative Refineries, Ltd. Consumer's refinery at Regina, Saskatchewan, Canada, has been modernized with a 4500 bbl per day charge capacity fluid catalytic cracker, to operate on Leduc crude, a gas recovery system, a vacuum unit, and a polymerization unit. Equipment was installed, engineered, and designed by UOP.

★ ★ ★

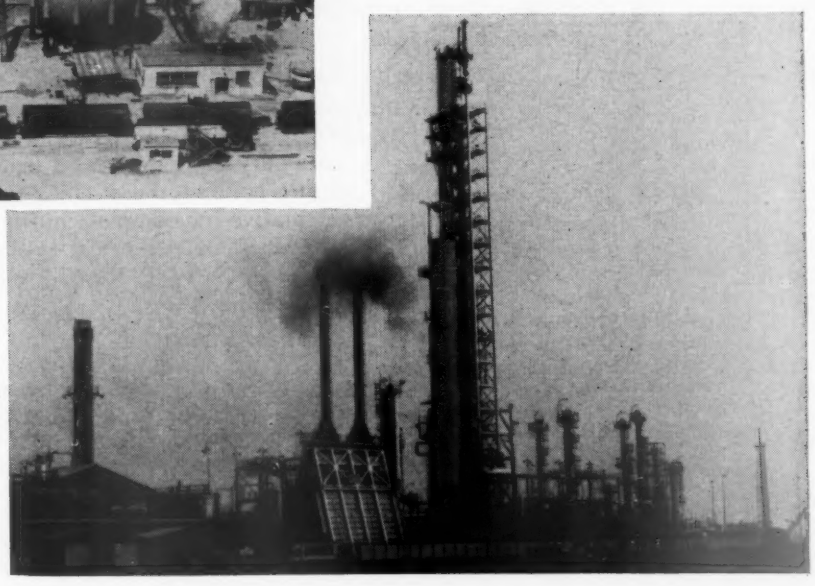
Mississippi Chemical Corporation. In boosting its ammonia capacity at Yazoo City from 120 tons to 290 tons daily, the company has two projects under way, a third completed. Girdler Corporation is doing the design engineering and construction of the new facilities. In the new conversion furnace the Girdler G-29 nickel base hydrocarbon-steam reforming catalyst is employed. In a second project the 1000-atmospheres (14,700 psig) step is being replaced by a low pressure methanation step. Third project is a fourth multitube reformer furnace that will bring the second purification train up to full capacity.

★ ★ ★

Sun Oil Company. Sun will build an ammonia unit at its Marcus Hook, Pennsylvania refinery. It will also use catalytic byproduct hydrogen from its refinery cat reforming units. Capacity will be 300 tons per day, to match the Indiana Standard-Sinclair unit to go up at Hammond, Indiana. A new hydrogen-and-catalyst lubricating oil treating unit, otherwise unidentified, will also be built soon.

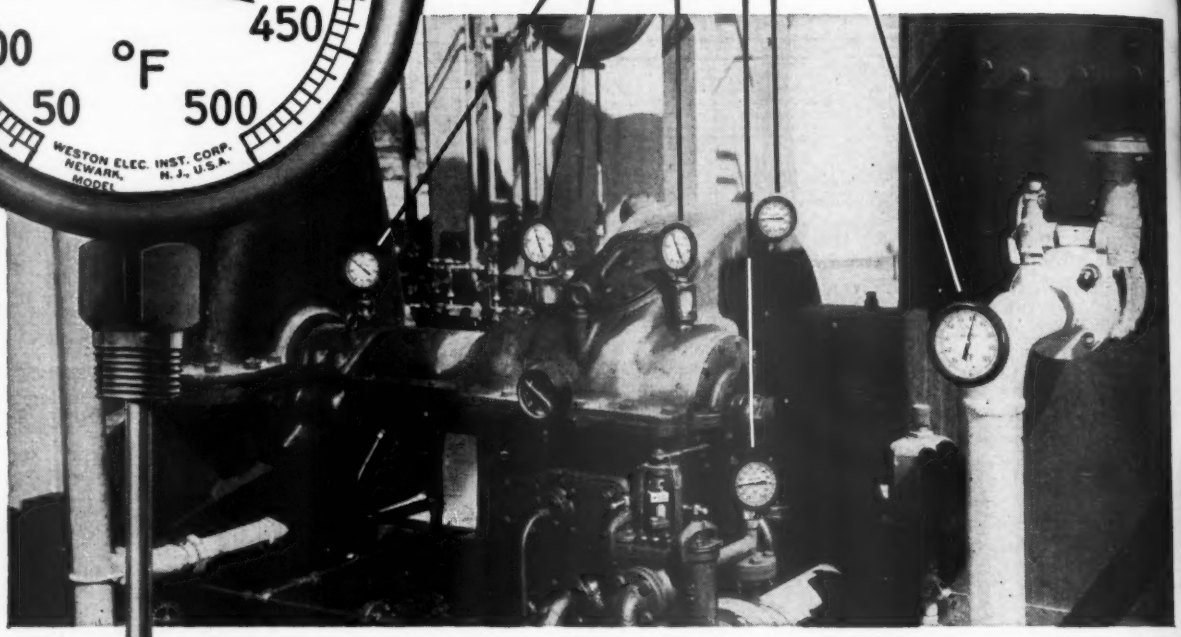


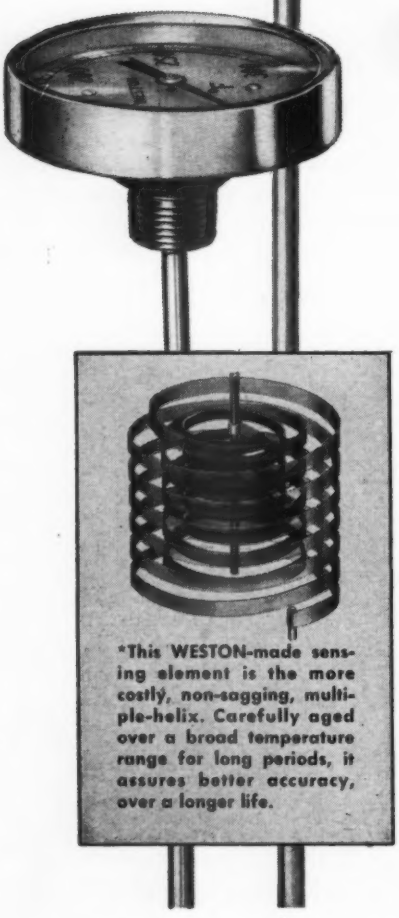
Albatros's houdriflow catalytic cracking unit and reactor kiln (center) at Antwerp, Belgium. Installation is undergoing heating up and drying out process.



Mississippi Chemical Corporation's ammonia plant at Yazoo City. Plant's capacity has been more than doubled by addition of new facilities.

AT EVERY CHECKPOINT





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(with Multiple Helix)*

Here's another typical example of how large processing plants have solved temperature checking problems, and cut thermometer costs besides. With a WESTON dial-type thermometer at every checkpoint, temperatures are read at a glance . . . in far less time, and with far greater accuracy. Their sturdy all-metal construction resists breakage, gives them far longer life on operating equipment. And the exclusive WESTON multiple helix employed assures dependable accuracy during all this long life.

Available in a broad selection of types, sizes, ranges and stem lengths, WESTON thermometers are today standard on all types of mobile and stationary equipment and machines, large and small; as well as on piping, conduit, ducts, etc. Ask your distributor, or local WESTON representative for complete information, or write for descriptive bulletin . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

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Fig. 2562—Gaso economy in a large-capacity unit especially adapted to gathering and main line service.

Gaso distributors, listed below, combine a first-hand knowledge of local conditions and requirements with a practical knowledge of the Gaso line. They are good people to know, helpful people to contact for a sound solution of any problem involving portable pumping units.

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NORTEX ENGINE & EQUIPMENT CO., Wichita Falls, Texas
LUFKIN FOUNDRY & MACHINE CO., Casper, Wyoming

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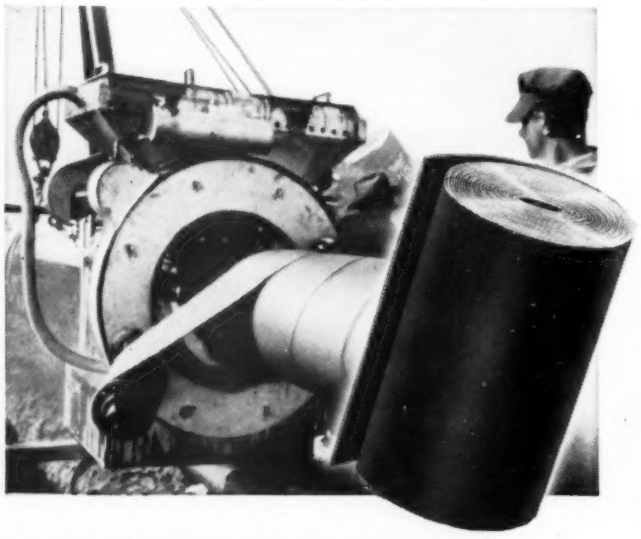
...cut maintenance expense increase pipe life

TRANSHIELD Asbestos Felt—

This newly developed low cost pipe line protecting wrapper is designed for average soil conditions. It is reinforced with continuous glass yarns, parallel spaced on ¼″ centers to give tear-free application strength. Made of coal-tar saturated asbestos, it acts as a continuous barrier to shield pipe line enamels from earth loads and soil stresses.



15-LB. ASBESTOS Pipe Line Felt—

A heavy-duty material particularly suitable for severe soil conditions or where a heavier material than J-M Transhield is desired. Provides long life, toughness, flexibility, resistance to rot, decay, cracking, and impact. J-M 15-lb. Asbestos Felt now protects more than 100,000 miles of oil and gas pipe lines. Widths 2″ to 36″. Rolls any length desired.

TRANTEX® Polyvinyl Tape—

A widely used coating where ease of application is important . . . over field welded joints of mill-wrapped pipe . . . for rush coating needs. Pressure-sensitive . . . sticks to pipe on contact, forming a firm stable bond. Can be cold-applied by hand or with simple wrapping machines. In rocky soils, an outer wrap of J-M Transhield or J-M 15-lb. Asbestos Pipe Line Felt is recommended.

For further information about Johns-Manville Products for Pipe Line Protection, write to Johns-Manville, Box 60, New York 16, N. Y.; in Canada, 199 Bay St., Toronto I, Ont.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PRODUCTS FOR PIPELINE PROTECTION

Feast to Famine

Supplies of gas for interstate shipment are drying up—and possibly faster than is readily seen. In New York, API president Frank M. Porter told 1000 industry and business leaders at an Oil Progress Week luncheon that producers can't survive under utility control. And he noted that with one-third of the gas that goes into interstate commerce directly associated with petroleum production, the country's supply of petroleum could be adversely affected.

Pipe line company gas supply departments are doing little, if any, business in picking up small supplies.

Producers, whenever possible, are sitting tight. Most are waiting for relief from the regulation imposed by the Supreme Court's interpretation of the natural gas act. The producers are in hopes that congress will rectify the situation.

Most detrimental effect of the current controversy is on new pipe line construction and expansion programs. Already one project is held up (American-Louisiana) and promotion of other new gas lines has ground to a halt.

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Delay Supply Case

No action will be taken by the FPC on complaints by Texas-Illinois Natural Gas Pipeline Company against a group of independent natural gas producers until they have filed replies. The pipe line company recently filed two complaints against a group of 14 producers from cutting off gas sales under "escape clauses" written into original sales contracts, which provide for termination of service if the FPC should start regulating any phase of producer's activities. Replies were to be filed by October 29 and hearings will be held after the FPC reviews both sides of the controversy.

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Ohio Line Underway

Buckeye Pipe Line Company has begun construction of an 82-mile, 8-in. products line between Lima and Columbus, Ohio. Contractor for the project is Sheehan Pipe Line Construction Company, Tulsa, Oklahoma. Line is an extension of Buckeye's existing midwest system. Buckeye will also convert an existing 8-in. crude line between Toledo and Lima to products service, for a total addition of 165 miles.

Union Line Underway

Construction has begun on a 65-mile, 12-in. crude line by Union Oil Company from its Torrey lease near Santa Paula to the Los Angeles refinery. Completion is slated for early April, 1955. Line will have an initial capacity of 50,000 bbl daily with one station, located at Torrey. Crude from several areas will be blended at the Torrey station.

★ ★ ★

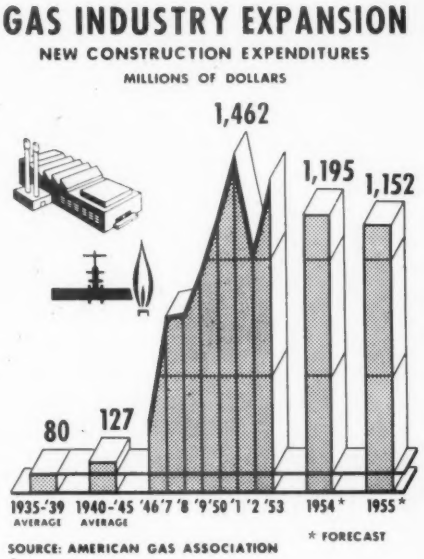
Line Expansion Completed

Construction has been completed on 717 miles of new lines in the current expansion program of Great Lakes Pipe Line Company. A total of 353 miles of 12-in. lines and 364 miles of 8-in. lines comprise the expansion program. Completion of new and expanded pumping stations will follow within a few weeks.

★ ★ ★

Gas From Canada

A 25-year contract to buy gas from Trans Canada Pipelines, Ltd., has been signed by Northern Natural Gas Company. Company proposes to take delivery beginning October 27, 1955, at a rate of 100,000,000 cu ft daily. Contract is contingent on obtaining the necessary government permits and completing financing. Delivery of the gas would take place on the international boundary north of Williston Basin. Northern would then be in position to combine Canadian and Williston gas and construct a line across North Dakota to tie-in its system.



Product Deliveries High

Petroleum products movements via pipe line for the first 7 months of 1954 topped a similar period in 1953 by 14.6 per cent. In the January-July period, deliveries were 363,957,000 bbl contrasted to 317,700,000 for the previous year period.

★ ★ ★

Restricted Approval Given

In a surprise move, the FPC approved the 1300-mile American-Louisiana Pipe Line project, but imposed restrictions that may keep the line from being built for some time. Order restricts construction commencement until the independent producers who are to supply the line have applied for and received FPC authorization. A certificate granted Texas Gas Transmission Corporation at the same time contained the same restriction. Texas Gas will supply part of the gas requirements of American-Louisiana.

★ ★ ★

Air Base Pipe Lines

Delivery of petroleum products, especially jet fuels, by pipe line to its air bases is being studied by the Air Force. A test contract with Phillips Petroleum Company will deliver jet fuel from Phillips's Borger-Chicago pipe line to the Kaneb Pipe Line and then to the Smokey Hill Air Base in Kansas. Other suppliers to the Air Force have expressed interest in the test towards possible future operations of a similar nature.

★ ★ ★

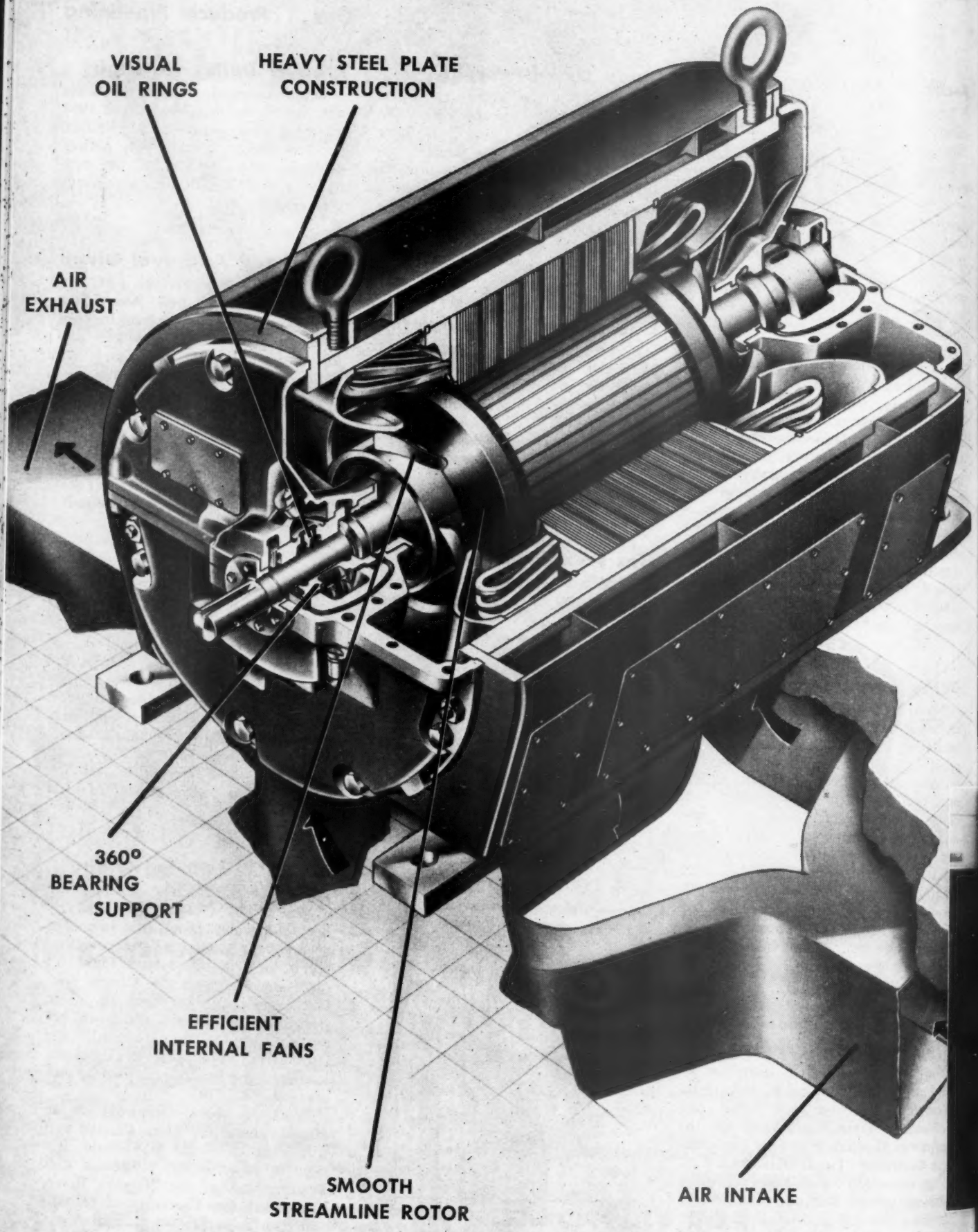
Trans Canada Surveying

Surveying is underway on the route of the Trans Canada pipe line by Bechtel-Mannix-Hester, firm in charge of design, engineering, and construction of the 2200-mile system. Plans call for 36-in. line from the Alberta- Saskatchewan border to Winnipeg, 30-in. from there to Toronto, and 24-in. between Toronto and Montreal. The latter from Winnipeg to Emerson, Manitoba, on the international boundary, will be 24-in.

Work has been completed on an 80-mile lateral for Trans Canada that will bring U. S. gas to Toronto. Import is supplied by Tennessee Gas Transmission at the Niagara River. Consumer's Gas Company of Toronto will distribute the gas. Canadian gas is expected to be available by 1956.

XUM

G-E two pole motor typical of construction below 1000 h.p.



G-E enclosed base-ventilated motors eliminate ugly piping; need no firewall

Here's a motor that improves the appearance of your pipe-line pumping station. General Electric's enclosed base-ventilated motor has air intake and discharge ducts located below floor level eliminating unsightly piping.

General Electric enclosed base-ventilated motors are built without limitation in size and give you the advantages of low cost and all-around protection. Here are some of the features that make this motor particularly suitable for pipe-line pumping applications.

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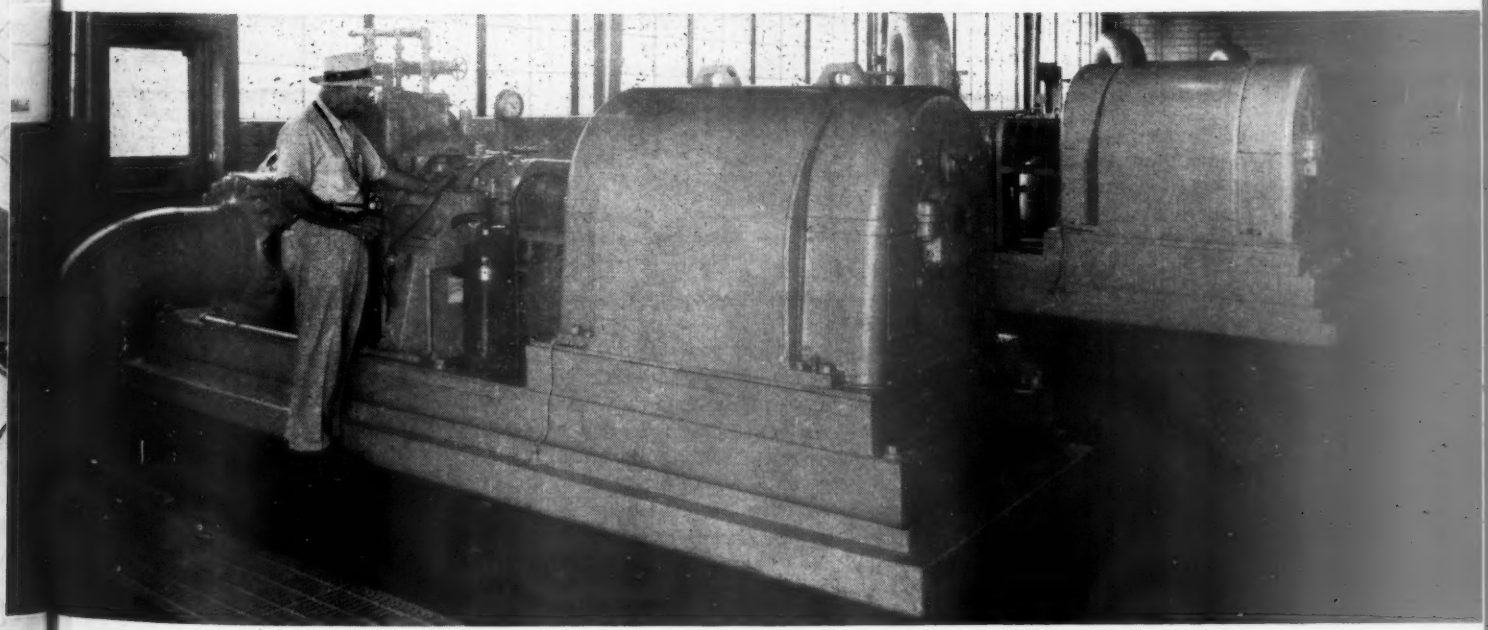

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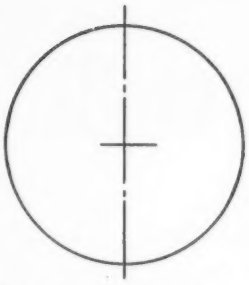
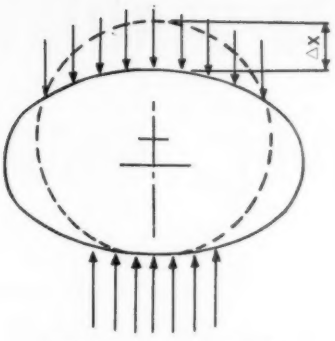
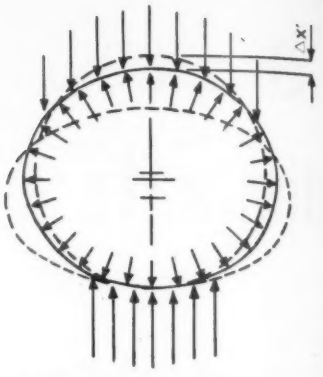


(a) No external load
No internal pressure



(b) External load only
No internal pressure



(c) External load plus
internal pressure

Secondary Stresses in Buried High Pressure Pipe Lines

Primary sources of secondary stresses are backfill loads and traffic loads; article explores their magnitudes in combination with stresses caused by internal fluid pressure

M. G. SPANGLER

TENTATIVE drafts of the proposed Code for Gas Transmission and Distribution Piping Systems define secondary stresses in pipe lines as stresses created in the pipe wall by loads other than internal fluid pressures. Two very prevalent sources of secondary stresses in transmission pipe lines are backfill loads and traffic loads. The purpose of this article is to explore the magnitude of stresses due to these external load sources when they occur in combination with stresses caused by internal fluid pressure.

When steel line pipe is assembled and laid prior to being covered with earth. it is nominally in a circular shape. After covering, the vertical load on the pipe from the earth backfill causes it to deflect to an elliptical shape with the major axis horizontal and the minor axis vertical. When internal pressure is introduced into the pipe, the resultant of vertical components of this pressure will be greater than the resultant of horizontal components because of the elliptical shape. This excess vertical internal pressure against the upper half of the pipe acts in opposition to the vertical external load and combines with the resilience or stored energy in the deflected pipe to resist the external load.

Under these conditions, equilibrium of forces on the pipe will prevail when the sum of the vertical excess pressure plus the resilience in the deflected pipe is equal to the external load. This means that when internal pressure is introduced into a pipe, which has been deflected by external load, the deflection will decrease to some equilibrium value and the shape of the pipe will be stablized as an ellipse intermediate be tween a circle and the deflected shape under external load alone.

The bending stresses in the pipe wall corresponding to this equilibrium deflection, which are less than the stresses due to external load without internal pressure, are assumed to be algebraically additive to the tensile hoop stress due to internal pressure. The deflections of a pipe under various load and pressure situations are shown in Fig. 1.

The above hypothesis can be expressed in mathematical formulas that facilitate the calculation of combined primary and secondary stresses in the pipe wall.

The primary bursting or hoop stress in the pipe can be computed by the formula:

$$S_1 = \frac{p(D-2t)}{2t} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which

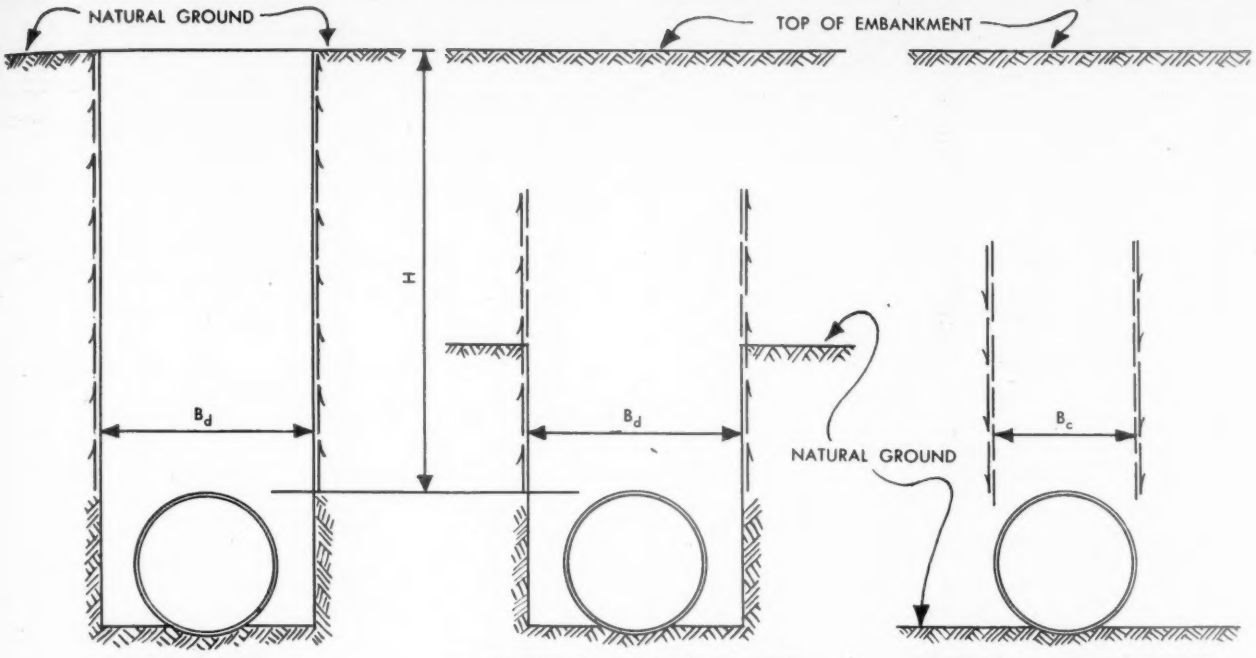
S_1 = circumferential tensile stress in pipe wall due to internal pressure, psi
p = internal fluid pressure, psi
D = outside diameter of pipe, in.
t = thickness of pipe wall, in.

Underground pipe lines may be installed under a wide variety of environmental conditions that influence the amount of load produced by the earth cover. The subject of loads on buried conduits has been studied extensively at Iowa State College over the past 45 years. These researches led to the development of Marston's Theory of Loads on Underground Conduits, which is widely used in the design of pipes in the sewerage, drainage, and water and gas distribution fields of en-

The Author

M. G. Spangler is research professor of the Civil Engineering Department at Iowa State College. Spangler is a graduate of Iowa State with degrees of Civil Engineer and Master of Science. He was a bridge designer with the Iowa Highway Commission before returning to Iowa State in 1924 to join the research staff of the Iowa Engineering Experiment Station. He was associated with the late Anson Marston in research on underground conduits and other problems in soil engineering. Spangler was Research Associate Professor before being advanced to his present position in 1947.

EXCLUSIVE



(a) Ditch conduit (b) Negative projecting conduit (c) Positive projecting conduit

FIG. 2.

gineering. It is believed to be equally applicable to the study of external loads on transmission pipe lines in the petroleum industry.

There are three major classifications of installation conditions that influence the magnitude of the earth load on an underground conduit. These are the conditions that prevail when a pipe is installed in a relatively narrow ditch, and those that prevail when a pipe is installed under an embankment. Conduits under embankments are further subdivided into positive projecting conduits and negative projecting conduits, depending upon whether the top of the conduit, as installed, is at an elevation above the adjacent natural ground or below the natural ground level. These classifications are illustrated in Fig. 2.

Loads On Pipe

The load on an underground pipe line is dependent upon the weight of the prism of soil over the pipe and upon vertical shearing forces that are induced by unequal vertical movements or settlements of the soil prism over the pipe in relation to the soil at the sides of the prism. The resultant load on the line is equal to the weight of the soil over the pipe plus or minus the value of the induced shearing forces, depending upon the direction of the relative movements between the prism of soil over the pipe and that adjacent thereto. The direction of induced shearing forces in the major classes of buried pipe installations are shown in Fig. 2.

Marston's formula for loads on buried conduits is:

$$W_c = \frac{1}{12} CwB^2 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which

W_c = load on conduit, lb per lin in.
w = unit weight of soil, lb per cu ft
B = width factor, ft
use B_d = width of ditch at elevation of top of pipe for ditch conduits and negative projecting conduits
use B_c = outside width of pipe for positive projecting conduits
C = load coefficient
use C_d for ditch conduits
C_c for positive projecting conduits
C_n for negative projecting conduits

Transmission pipe lines are practically always installed in ditches of widths approximately 6 to 12 in. greater than the outside diameter of the pipe, and when so installed, are properly classified as ditch conduits. Equation 2 may appropriately be used to calculate the load on the pipe, using B_d as the width factor and C_d for the load coefficient. In locations where a pipe line is constructed and then covered by an earth fill, such as a railway or highway embankment, levee or an earth dam, the ditch conduit load formula may not apply and a special study of the earth load on the pipe should be conducted.

The load coefficient C_d is dependent upon the coefficient of internal friction of the soil backfill and the ratio of height of fill H, to the width of ditch, B_d. Values of C_d for various values of $\frac{H}{B_d}$ are given in Table 1.

Deflection of Pipe

Having obtained the amount of the external load on a pipe line, the next step toward the determination of combined stresses in the pipe wall is to calculate the deflection of the pipe, first under external load only and second under combined external load and internal fluid pressure. There are available in the literature two methods of approach to the calculation of pipe deflections due to external loads. One is to assume that a state of *plain strain* exists; that is, that the pipe is infinitely long and contains identical forces in every cross section. It is assumed that no deformation occurs in the direction normal to a cross section and consequently stresses and deflections which

TABLE 1. Values of C_d.
(Ordinary maximum for clay backfill)

Ratio $\frac{H}{B}$	Cd	Ratio $\frac{H}{B}$	Cd
.1	.10	2.1	1.62
.2	.20	2.2	1.68
.3	.29	2.3	1.73
.4	.38	2.4	1.78
.5	.47	2.5	1.84
.6	.56	2.6	1.89
.7	.64	2.7	1.94
.8	.72	2.8	1.99
.9	.80	2.9	2.04
1.0	.88	3.0	2.08
1.1	.96	3.1	2.13
1.2	1.03	3.2	2.18
1.3	1.11	3.3	2.22
1.4	1.18	3.4	2.26
1.5	1.24	3.5	2.30
1.6	1.30	3.6	2.34
1.7	1.37	3.7	2.38
1.8	1.43	3.8	2.42
1.9	1.50	3.9	2.46
2.0	1.56	4.0	2.49

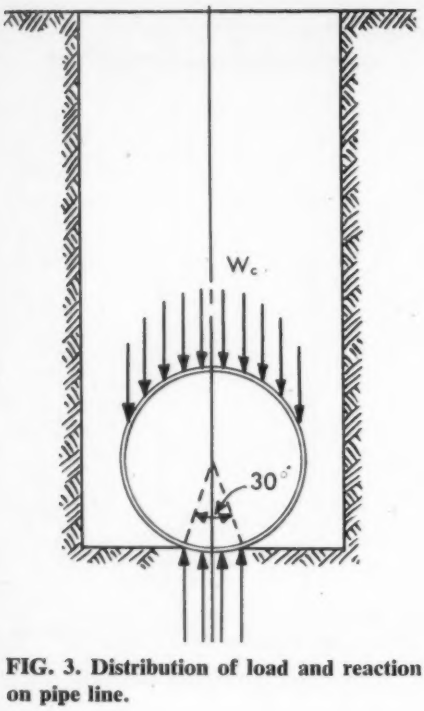


FIG. 3. Distribution of load and reaction on pipe line.

depend upon Poisson's ratio act upon every cross section.

The formula for vertical deflection of a pipe under vertical load and in a state of plane strain is:

$$\triangle X = N \frac{W_c r^3 (1 - \eta^2)}{EI} \quad . \quad . \quad (3)$$

in which

$\triangle X$ = vertical deflection, in.
N = a parameter that is a function of the lateral distribution of the load and reaction.
W_c = load on pipe in lb per lin in.
r = mean radius of pipe, $= \frac{D - t}{2}$, in.
η = Poisson's ratio of pipe metal.
E = modulus of elasticity of pipe metal, psi
I = moment of inertia of pipe wall, in 4 per in. $= \frac{t^3}{12}$

The second approach to the calculation of pipe deflection is to assume that a state of *plane stress* exists; that is, that the pipe metal is free to deform in the direction normal to a cross section and consequently no stresses due to Poisson's ratio act upon either end of a short segment of the pipe.

The formula for vertical deflection of a pipe under vertical load and in a state of plane stress is:

$$\triangle X = N \frac{W_c r^3}{EI} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which the notation is the same as for equation 3.

Theoretically, it would appear that a pipe line more nearly conforms to the condition of plane strain, since the pipe is very long. Initial longitudinal stresses in the pipe due to slack laying and uneveness of the bottom of the ditch may modify this condition to the extent, however, that it is impossible to say definitely which of the two conditions most nearly applies. Therefore, in this analysis, equation 4 will be used, since it gives somewhat greater deflection than equation 3.

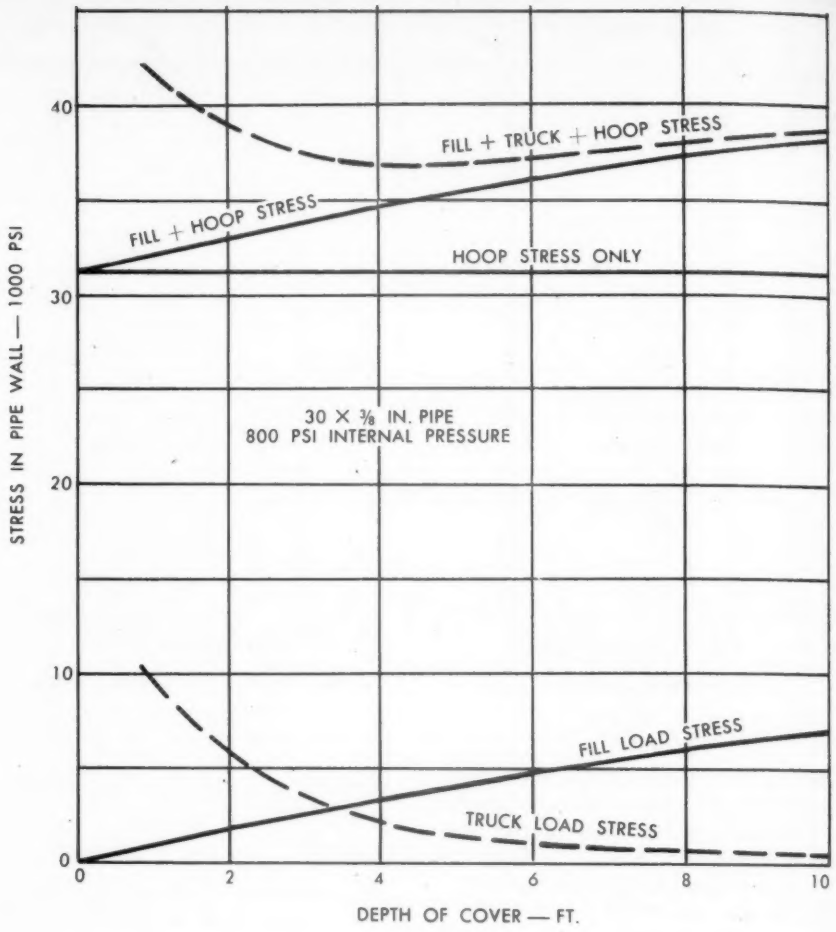


FIG. 4.

In order to evaluate the parameter N in equation 4, it is necessary to assume a reasonable situation with respect to the transverse distribution of the vertical load and reaction on the pipe. Research on pipes used in sewerage and drainage work indicates, as a generalization, that the earth load is distributed approximately uniformly over the full width of the top of the pipe. The reaction on the bottom, however, is distributed over a much narrower width depending upon the width of contact between the pipe and the bottom of the ditch.

It is not usual practice in the pipe line industry to shape the bottom of the ditch to fit the contour of the pipe. The width of contact, therefore, is dependent upon the amount which the pipe pushes into the soil bedding due to the vertical earth load and its own weight. Under these circumstances it is doubtful whether the bottom reaction would be distributed over a width greater than about 30 deg. These assumed distributions of load and reaction are shown in Fig. 3.

The corresponding value of N is 0.108 and the value of the deflection of a circular pipe under external vertical load in this analysis is expressed by the formula:

$$\triangle X = 0.108 \frac{W_c r^3}{EI} \quad . \quad . \quad (5)$$

The horizontal deflection of the pipe is substantially the same as the vertical deflection. Therefore the inside vertical diameter of the deflected pipe is $(D - 2t) - \triangle X$ and the inside horizontal diameter is $(D - 2t) + \triangle X$. The difference between these diameters is $2\triangle X$, which is the amount by which the horizontal diameter is greater than the vertical diameter. When internal pressure is introduced into the deflected pipe, the excess vertical pressure over the horizontal pressure will be $2p\triangle X$.

This excess vertical pressure causes a reduction in the deflection of the pipe. In other words, the pipe has a tendency to return toward the circular shape as shown in Fig. 1(c). A new equilibrium deflection will be established when the sum of the excess vertical pressure plus the resilience in the pipe is equal to the external load. Thus, we may write:

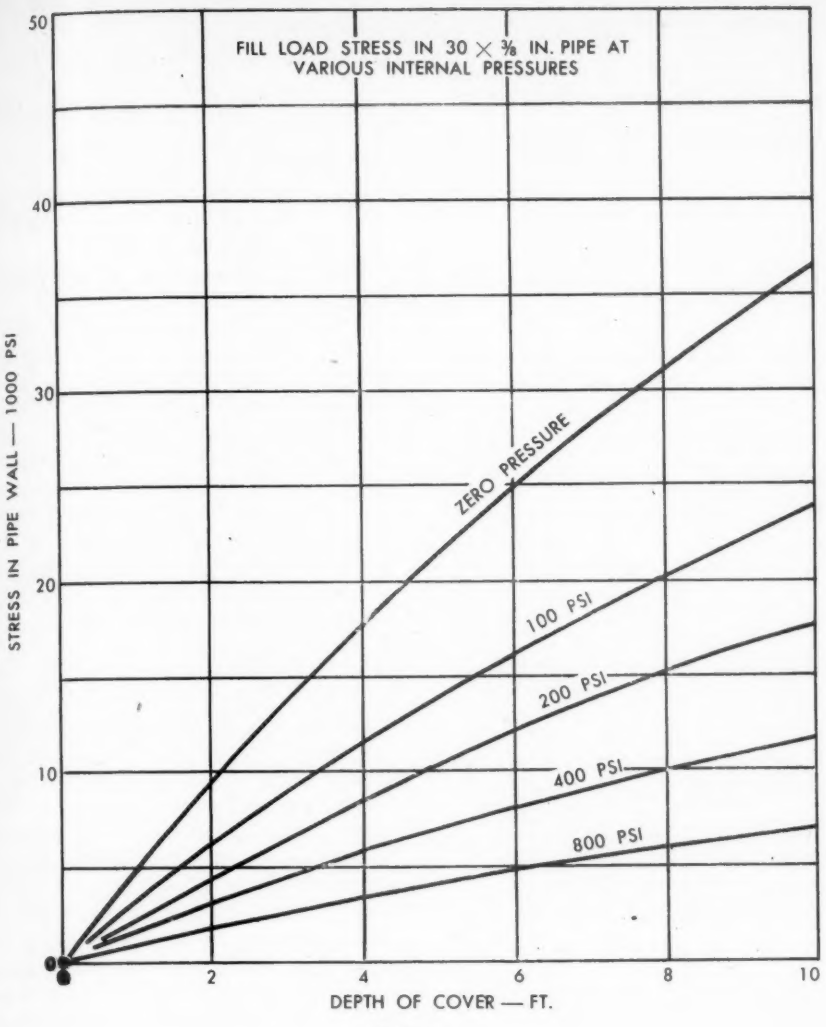


FIG. 5.

$$W_e = \triangle X' \frac{W_e}{\triangle X} + 2p\triangle X' \quad . \quad . \quad (6)$$

in which

$\triangle X'$ = equilibrium deflection under combined internal pressure and external load, in.

Transposing and substituting equation 5 in equation 6

$$\triangle X' = 0.108 \frac{W_e r^3}{EI + .216\ pr^3} \quad . \quad . \quad (7)$$

The external load bending moment is maximum at the bottom of the pipe and at the equilibruim deflection is:

$$M'_B = 2.170 \frac{\triangle X' EI}{r^2} \quad . \quad . \quad . \quad . \quad (8)$$

Substituting equation 7 in equation 8:

$$M'_B = .234 \frac{W_e rEI}{EI + .216pr^3} \quad . \quad . \quad . \quad (9)$$

Then the tensile stress at the bottom of the pipe due to bending is, by the flexure formula:

$$S_2 = \frac{M'_B}{2I} t \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Substituting equation 10 and equation 2 and $I = \frac{t^3}{12}$ in equation 9:

$$S_2 = .117 \frac{C_d w B^2_d Etr}{Et^3 + 2.592pr^3} \quad . \quad . \quad (11)$$

Equation 11 is an expression for the maximum bending moment stress at the bottom of a pipe subjected to both external fill load and internal fluid pressure. The maximum combined stress may be obtained by adding equation 1 and equation 11:

$$S = S_1 + S_2 = \frac{p(D - 2t)}{2t} + .117 \frac{C_d w B^2_d Etr}{Et^3 + 2.592pr^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

in which

S = maximum combined stress due to external fill load and internal pressure, psi

S_1 = hoop stress due to internal pressure, psi

S_2 = bending stress due to external fill load, psi

C_d = calculation coefficient for external fill load on ditch conduits

w = unit weight of soil backfill, pcf

B_d = width of ditch at level of top of pipe, ft

E = modulus of elasticity of pipe metal, psi

t = thickness of pipe wall, in.

r = mean radius of pipe, in. $= \frac{D - t}{2}$

In this equation all factors are in inch units except w and B which are in feet. The numerical coefficient of the second term, however, has been adjusted so that the result is in pounds per square inch.

Highway Traffic Loads

When a pipe line is constructed in a street or roadway without a protective casing the wheels of traffic vehicles may produce loads on the pipe that induce secondary stresses in the pipe wall. These stresses, like those due to the earth fill will be additive to the bursting stress.

Extensive research conducted at the Iowa State College has indicated that the maximum probable load that is transmitted to an underground pipe from a truck wheel acting at the surface can be calculated with a reasonable degree of reliability by the Boussinesq solution for stress in the interior of a semi-infinite elastic mass due to a point load applied at the surface.

These studies indicated that the actual load transmitted to the pipe varies over a considerable range, apparently due to fortuitous combinations of conditions that are not identifiable in advance of the application of a truck wheel load. The Boussinesq solution, however, provides a locus of stress value that was sometimes equalled but never exceeded in a large number of trials. Also, it is pointed out that the trials were conduced with a gravel surfaced roadway. No similar experiments have been conducted with a high type rigid pavement such as Portland cement concrete.

The studies were made with both static and moving loads. Moving loads produced an impact increment of load on the buried pipe, which was a function of the speed of the vehicle in relation to the roughness characteristics of the roadway surface, but it was independent of the depth of cover. That is to say, the impact factor for two feet of cover was about the same as for six feet of cover, although the percentage of the applied wheel load that reaches the pipe under the greater depth is much less.

Experimental impact values obtained were very high under some very adverse roadway conditions such as 2-in. and 4-in. obstructions on the surface or deep chuck holes. For general use, however, an impact factor of about 1.5 is recommended.

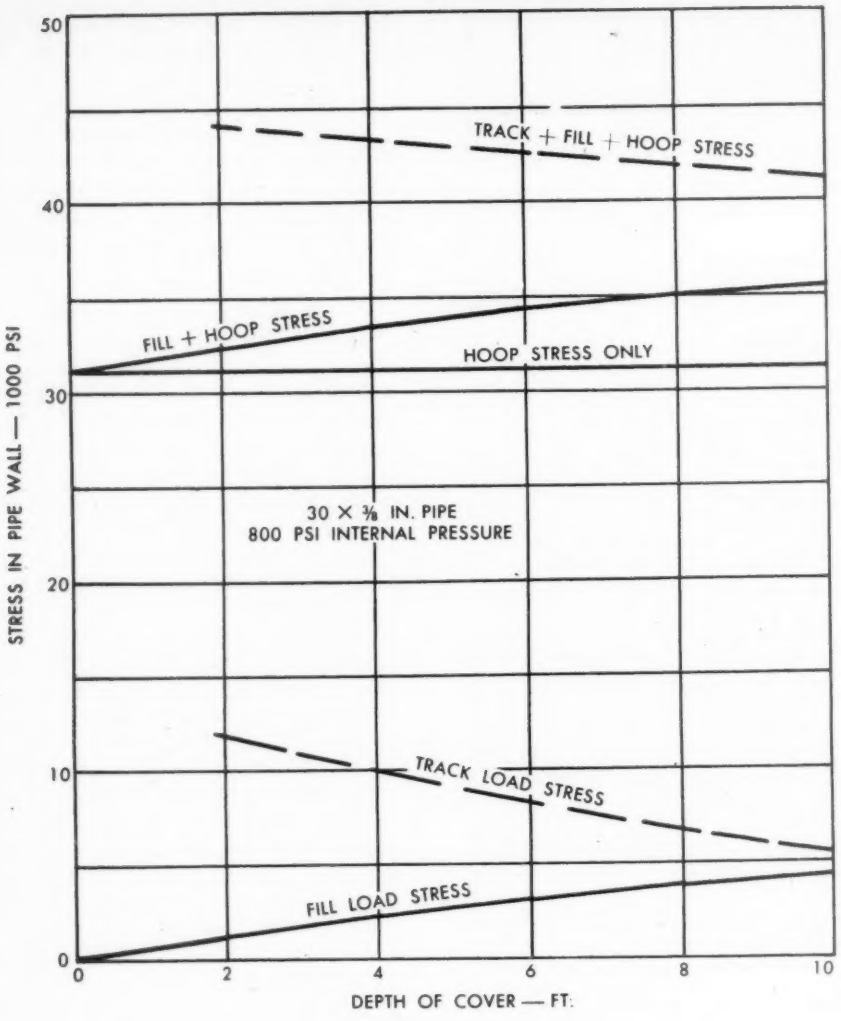


FIG. 6.

TABLE 2. Influence coefficients, C_t, for truck wheel applied above center of pipe of diameter D and length L, at depth below surface (Boussinesq theory).

D / $\frac{L}{2H}$	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.2	1.2	1.5	2.0
2H													
.1	.019	.037	.053	.067	.079	.089	.097	.103	.108	.112	.117	.121	.124
.2	.037	.072	.103	.131	.155	.174	.189	.202	.211	.219	.229	.238	.244
.3	.053	.103	.149	.190	.224	.252	.274	.292	.306	.318	.333	.345	.355
.4	.067	.131	.190	.241	.284	.320	.349	.373	.391	.405	.425	.440	.454
.5	.079	.155	.224	.284	.336	.379	.414	.441	.463	.481	.505	.525	.540
.6	.089	.174	.252	.320	.379	.428	.467	.499	.524	.544	.572	.596	.613
.7	.097	.189	.274	.349	.414	.467	.511	.546	.574	.597	.628	.650	.674
.8	.103	.202	.292	.373	.441	.499	.546	.584	.615	.639	.674	.703	.725
.9	.108	.211	.306	.391	.463	.524	.574	.615	.647	.673	.711	.742	.766
1.0	.112	.219	.318	.405	.481	.544	.597	.639	.673	.701	.740	.774	.800
1.2	.117	.229	.333	.425	.505	.572	.628	.674	.711	.740	.783	.820	.849
1.5	.121	.238	.345	.440	.525	.596	.650	.703	.742	.774	.820	.861	.894
2.0	.124	.244	.355	.454	.540	.613	.674	.725	.766	.800	.849	.894	.930

On the basis of the above mentioned researches, it is possible to write an equation for the load on a buried pipe line caused by a moving truck wheel, as follows:

$$W_t = \frac{C_t P F}{12L} \quad . \quad . \quad . \quad (13)$$

in which

W_t = load on pipe due to truck wheel, lb per lin in.

P = truck wheel load, lb

L = effective length of pipe, ft. The length over which the average load produces the same stress as the actual load which varies in intensity from point to point along the pipe.

C_t = a load coefficient which depends on the diameter of the pipe, D; the effective length, L; and the height of fill above the top of pipe, H. Values of C_t may be taken from Table 2.

F = impact factor.

If it is assumed that the distribution of the load and reaction on the pipe due to a truck wheel load applied at the roadway surface is essentially the same as that of the fill load (see Fig. 3), then an equation for the bending moment stress at the bottom of the pipe can be written:

$$S_s = .117 \frac{C_t \frac{P}{L} FEtr}{Et^3 + 2.592pr^3} \quad . \quad . \quad (14)$$

in which

S_s = bending moment stress at bottom of pipe due to truck and impact loads, psi

Other symbols are as previously defined.

Probably the most uncertain factor in the above equation is the effective length, L. The writer does not know of any factual data upon which to base a choice of a numerical value of effective length. It remains purely a matter of judgment. In this study, a value of L = 3 ft has been assumed. Fortunately, the effect of this factor on the combined stress is relatively small in practical cases and large errors in assumed values are not critical.

Railway Traffic

When a pipe line is installed beneath a railroad track without a protective casing, secondary stresses will be induced in the pipe wall by the load produced by the earth cover and by the rail traffic. These loads may be estimated by the Marston theory and the Boussinesq theory respectively, as in the case of a pipe line under a highway. Rail traffic loads, however, should be treated as uniformly distributed loads over an area equal to the length of the locomotive multiplied by the length of railway ties. The method of computing loads on buried pipe lines under a railroad is given in detail in reference (4).

If the pipe line is installed in a ditch dug in the railway embankment, the backfill load may be calculated by equation 2, using B_d as the width factor. If the pipe is installed, however, by boring or tunneling through the embankment, the width factor will be the diameter of the bored hole.

Illustrative Examples

Several examples of calculations of external loads and combined primary and secondary stresses will be given to illustrate the methods suggested above.

For these examples, a 30 by ⅜-in. steel pipe operating at a pressure of 800 psi has been selected arbitrarily. The first calculation is for a pipe line installed in a ditch that is 12 in. wider than the diameter of the pipe, both in open country and under a highway (without casing).

Data for this calculation is:

D = 30 in.	**p = 800 psi**
t = ⅜ in.	**E = 30,000,000 psi**
w = 120 pcf	**B_d = 3.5 ft**
P = 10,000 lb	**F = 1.5**
L = 3 ft	**Ordinary clay soil**

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The primary stress, by equation 1, is:

$$S_1 = \frac{800(30 - .75)}{.75} = 31{,}200 \text{ psi}$$

For a depth of backfill H = 10 ft, $\frac{H}{B_d} = \frac{10}{3.5} = 2.86$ and from Table 1, $C_d = 2.02$.

The secondary stress for this depth of backfill, by equation 11, is:

$$S_2 = \frac{.117 \times 2.02 \times 120 \times 3.5}{30{,}000{,}000 \times .375^3} \times \frac{3 \times 10^7 \times .375 \times 14.8125}{+ 2.592 \times 800 \times 14.8125^3} = 8360 \text{ psi}$$

If this pipe passes beneath a highway, the stress in the pipe wall, due to truck traffic, may be calculated by equation 12. The value of C_t may be taken from Table 2. For a depth of backfill, H = 2 ft, $C_t = .495$. A sample calculation of the truck wheel load stress is:

$$S_3 = \frac{.117 \times .495 \times \frac{10{,}000}{3} \times 1.5}{30{,}000{,}000 \times .375^3} \times \frac{3 \times 10^7 \times .375 \times 14.8125}{+ 2.592 \times 800 \times 14.8125^3} = 7000 \text{ psi}$$

The secondary stresses due to a backfill load and to highway traffic for a 30 by ⅜-in. pipe operating at 800 psi internal pressure and under various depths of cover up to 10 ft are shown in Fig. 4.

Fig. 5 illustrates how the bending moment stress due to backfill load decreases as internal fluid pressure increases.

Secondary stresses under railway traffic are shown in Fig. 6. For these computations, Cooper's E-70 loading plus 75 per cent impact was assumed. Also, the pipe line was considered to have been installed under the track in a bored hole of approximately the same diameter as the outside diameter of the pipe.

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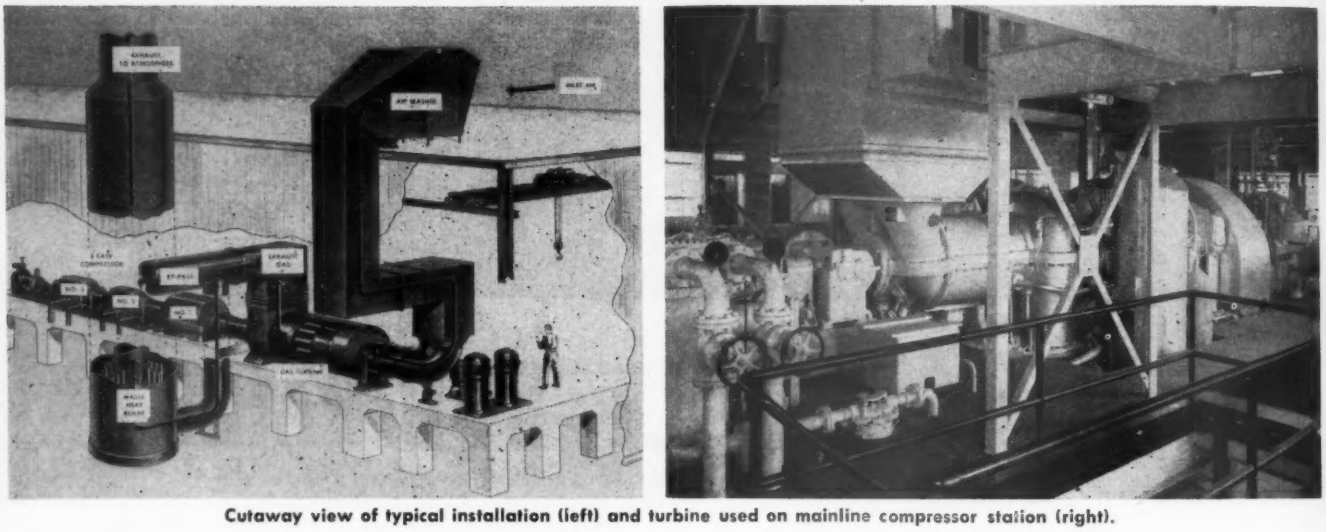


Cutaway view of typical installation (left) and turbine used on mainline compressor station (right).

Gas Turbine Usage Increase Ahead

E. C. CLARK*

The next 10 years will see a tremendous growth in the use of gas turbines as sources of inexpensive power in gas and petroleum applications.

The steadily accumulating record of good operating experience with the gas turbine will most likely stimulate its application in the future. In addition to installations for straight power generation and pipe line pumping, some applications where heat in the gas turbine exhaust gases can be recovered for other uses are very attractive.

Much experience and technological know-how has been gained by research on the part of the gas turbine manufacturers and customers. An example of such engineering progress is indicated by the increase in various turbine ratings. One model, originally rated at 5000 hp for simple and regenerative type, has increased to 7000 hp for the simple cycle units and 6700 hp for the regenerative cycle units. These increased ratings are the direct result of improved design and are realized without sacrificing reliability or quality.

Models have been improved further from an installation standpoint by factory mounting the turbines on steel bases and shipping the units with factory-assembled piping, oil tank, and wiring. This enables the base to become a permantent part of the foundation of the installation—thus reducing the costs for the over-all project.

The combustion gas turbine is a self-contained prime mover, and as such it is suitable for installation in isolated locations as well as interconnected systems.

Versatility of the equipment can be seen through its characteristics of simplicity, quick starting, minimum requirements for cooling water, and increased output with low ambient conditions.

The 28 gas turbines in operation on the El Paso Natural Gas Company's system represent the first large scale application of gas turbines for pipe line pumping. Immediate observations indicated and were later verified that gas turbine compressor stations could pump considerably more gas than they were designed to handle.

The first of the El Paso turbines went into operation on September 29, 1952. By the end of 1953, the 28 units had accumulated over 100,000 turbine-hours operation. At the present time operating experience of these units is accumulating at the rate of approximately 15,000 turbine-hours a month.

* * *

*Turbine engineer, General Electric Co.

XUM

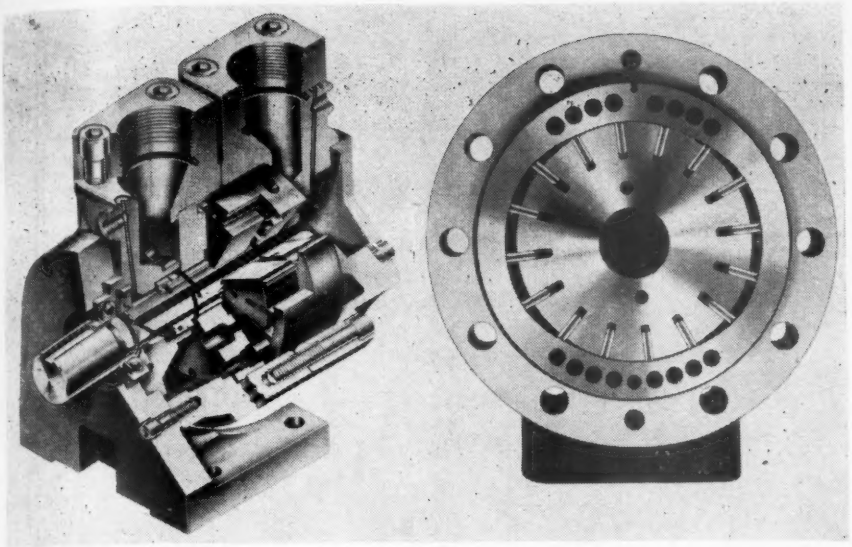


FIG. 6. High speed multi-vane motor. Left view shows cutaway section. Right, action of vanes.

The second of two comprehensive articles describes the types of mediums used to drive and control . . .

Remote Valve Operators

BURT OLIVE, JR. and M. M. HELLER*

HYDRAULIC high speed vane type motors as shown in Fig. 6, ninety degree turning vane type operators as shown in Fig. 7, and piston and cylinder operators as shown in Fig. 8, are being manufactured to operate on either liquids or gases. They may be controlled with either liquids, gases or electricity. Electric motor operators, electrically controlled, have probably enjoyed widest usage.

Oil and products lines commonly use electric motor valve operators, electrically controlled, as the contents of the lines may not be suitable as a power medium. Gas driven operators are being used on gas pipe line valves as gas is readily available at high pressures and may, in most cases, be exhaused to atmosphere.

High speed rotary vane type operators are popular because of their small size and ability to produce the necessary power to operate large high pressure valves speedily. Sufficient electrical energy is often not available to mainline valve locations at a reasonable cost. Even at some large compressor stations where ample lectrical energy is available, gas is used to power large valve operators. The availability of power for emergency shutdown systems preclude its use where a more substantial medium is applicable.

When natural gas is used to drive valve operators, gas may also be used as the control medium. Some gas transmission companies use a "fail safe" control system that is pressured at all times. Bleeding the pressure off by opening a valve at a control station actuates the emergency system.

Some gas transmission companies use gas operators with electrical controls. A small generator may be provided to start up and automatically keep an emergency control panel energized in event of power failure. Some companies use energized control systems that actuate a valve on power failure. Electrical controls are often favored because greater versatility can often be had at lower cost. Complete periodic checking of this control system may be made fast and simple.

*United Gas Pipe Line Company, Shreveport, Louisiana.

EXCLUSIVE

Cylinder Operators

The simpliest type of valve operator is that powered by a reciprocating piston in a cylinder. Wnen adapting this type of operators to gate valves, the cylinders may be fastened to the valve yoke and the piston to the valve stem. In this case, the piston strokes the valve directly. Some means of limiting the seating force in this type of installation is usually necessary to prevent jamming and yet provide full available force to unseat the valve.

When adapting a cylinder operator to the conventional type plug valve where the plug rotation is 90 deg, the piston may drive the plug by means of a rack and sector gear. Fig. 8A shows a plug valve and cylinder operator mounted to drive the plug in this manner. Both valve and operator may be purchased as a unit. Figs. 8B-C show other types.

This type of cylinder operator may also be operated by a handwheel located at the opposite end of the rack from the cylinder. The handwheel is geared to stroke the same rack that drives the sector gear. A "non-reopening" feature is incorporated in this operator to make it impossible for the valve to reopen after automatic closure until a special "slip key" is inserted between the sector gear and the plug shaft. This feature may or may not be used, depending on the type of control system. Extensions are available so that the valve operator may be installed above ground when the valve is installed below ground.

When a cylinder is adapted to operate a 90 deg turning plug valve, the stops on the valve should not be subjected to the full force of the piston. Preferably, stops should be provided within the cylinder operator to limit travel.

When a cylinder is used to operate a non-lubricated lift plug valve, the same type of seating action is desirable to seat and unseat the valve as was previously described for gate valves.

Either gases or fluids may be used to drive cylinder operators. In the gas transmission service, gas from the pipe line is often used to drive the piston, thereby eliminating auxiliary equipment necessary to handle oil. Some method of cylinder lubrication is necessary and a gas filter is usually desirable where gas is used directly to drive the piston.

Control systems for cylinder operators may use gases, liquids or electricity as control mediums. A 4-way valve is commonly used to direct the flow of the power medium, gas or liquid, to the cylinder. This 4-way valve usually has three operating positions, open, close, and neutral. A hand lever may be used to manually shift

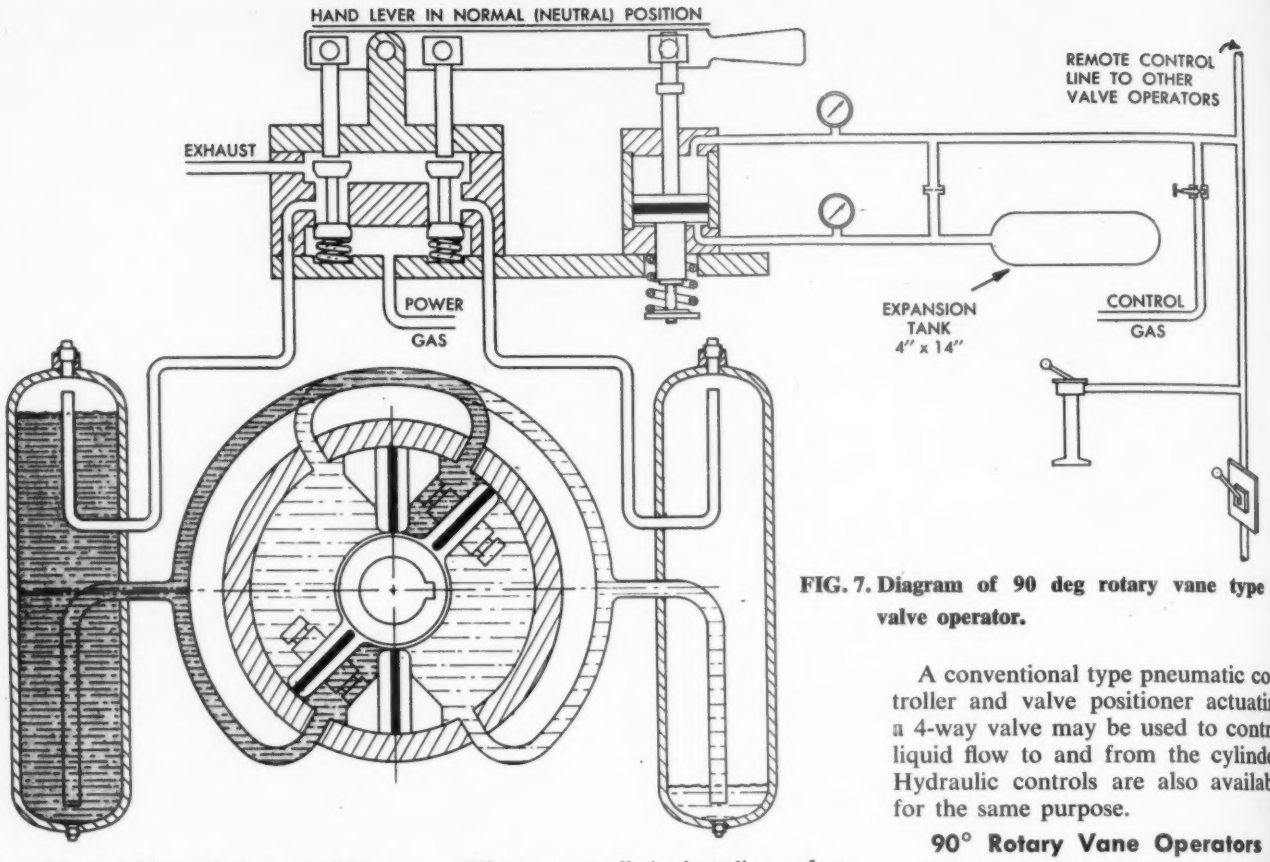


FIG. 7. Diagram of 90 deg rotary vane type valve operator.

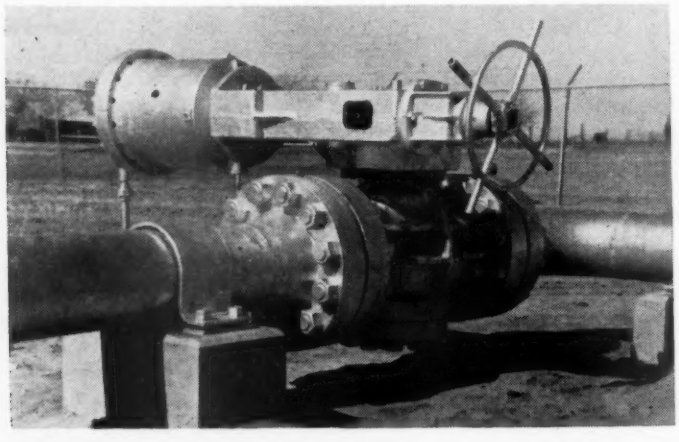
the valve to either of these positions as shown in Fig. 4, or solenoids may be employed to shift it in the case of an electric control system as shown in Fig. 3.

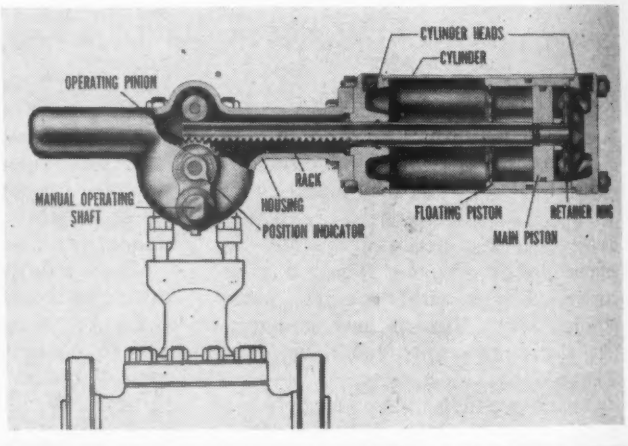
Where controlled throttling of a valve is desired, a fluid driven cylinder operator is most suitable because more precise positioning may be accomplished than is possible with gas drive.[1] A conventional type pneumatic controller and valve positioner actuating a 4-way valve may be used to control liquid flow to and from the cylinder. Hydraulic controls are also available for the same purpose.

90° Rotary Vane Operators

One type of rotary operator is being

[1] F. M. Partridge and C. C. Wilson described remote positioning of plug valves in their article entitled "Positioning of Piston-Operated Valves," which appeared in the January-February 1954 issue of *The Flowline*, published by Rockwell Manufacturing Company.





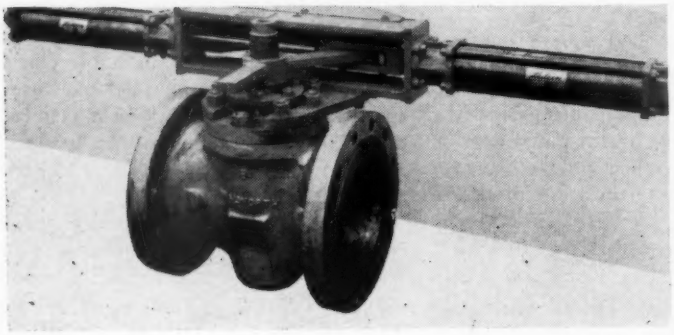


FIG. 8A. Top, left, cylinder and piston operator on a plug valve.

FIG. 8B-C. Lower left and right, top and bottom, other types of cylinder and piston operators.

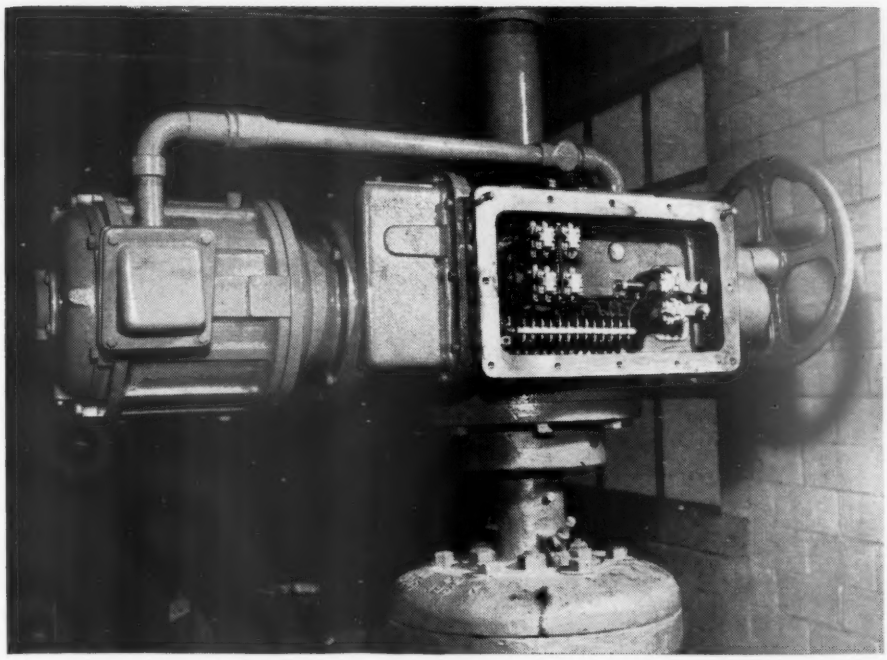


FIG. 10. Electric motor operator with automatic handwheel clutch mounted on a through conduit gate valve. Cover plate has been removed to show limit switches.

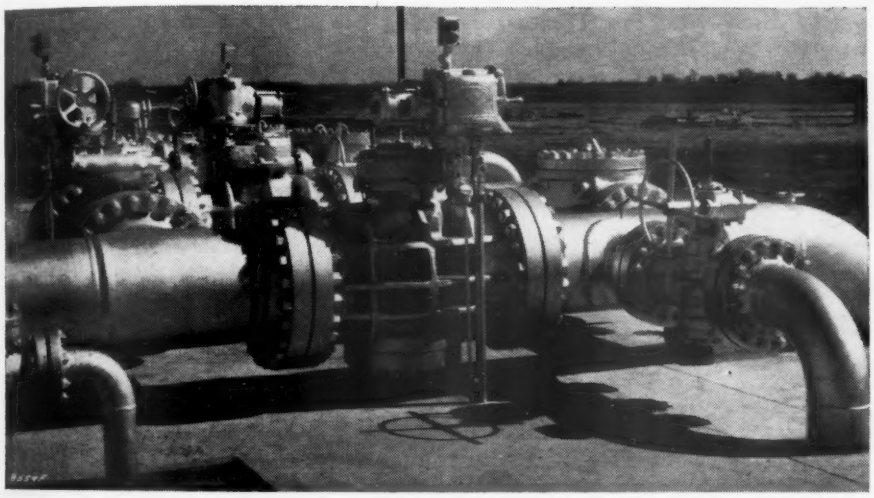


FIG. 9. Electric motor operators with handwheels and clutch levers mounted on plug valves.

manufactured especially for use on plug valves. This operator consists of two vanes mounted on a hub to rotate 90 deg within a cylindrical housing. The operator hub is attached to the valve's plug shank.[2,3]

Cylinder operators are seldom used on large high pressure pipeline gate valves because of their size, weight and cost of such a cylinder. Instead, motor operators with reduction gearing are generally used.

A practical reliable means of hand operation is necessary on many power operated valve installations, especially on pipe line valves. It may be necessary to use these valves before power is available from the pipe line. Although geared handwheel operation is usually provided with cylinder operators, a hydraulic hand pump may be used with an hydrauilc cylinder operator to operate the valve by transferring fluid from one side of the piston to the other. Likewise, a cylinder of inert gas may be used for any type of hydraulic operator for use when pipe line gas is not available.

Electric Motor Operators

Electric motor operators with both remote and local control have been used for power operation of valves for many years. They are well suited to electric remote control systems and are easily adapted to operate most any type of valve. In addition to the electric motor, which drives the valve through a gear train, the operator is equipped with a means of hand operaton with a declutching mechnism incorporated in the gear train. It is also equipped with limit controls that stop the motor automatically when the valve is opened or closed; a reversing motor starter; and various electrical control devices for starting, stopping, or delaying operations.

Two methods of limit control are employed in motor operators to limit travel. **Position** limit control stops the valve stem or plug at a predetermined set position at the end of the opening or closing stroke. **Torque** limit control stops the valve motor when a predetermined set amount of force has been applied to the valve stem. As the valve begins to seat, the thrust on the stem increases and a thrust spring begins to compress. When desired seating thrust is reached, a switch linked to the movable end of the thrust spring breaks a circuit stopping the motor.

The thrust spring is further compressed by the kinetic energy of the coasting motor and the other parts until they come to rest. This cushioning effect provides tight closure and prevents jamming. In high temperature service where the valve stem length might vary with temperature change enough to jam a seated valve, this same thrust spring would serve to prevent build up of excessive seating forces.

Accurate position control of closing is, in general, more satisfactorly than non-wedging types of valves where stem or plug movement is stopped always at the same position. This control is ideal for 90 deg rotation plug valves, but not for lift plug types that require seating. It is suitable for butterfly valves, for wedge or parallel face types of gate valves that stop flow by check action when the gate is in seating position, due to differential pressure across the gate or; for closures that are not required to be leak tight or; where the valve body temperature variation introduces expansion changes that make tight seating objectionable.

[2]C. W. Marvin described the 90 deg rotary vane type operator and suitable control systems in his article entitled, " Compressor Station Emergency Shut-off," which appeared in the October 1952 issue of *The Petroleum Engineer.*
[3]Mr. H. G. Davis of Columbia Gas System Service Corporation has conducted experiments to determine the operating characteristics of the 90 deg vane type operator, and has examined various methods of control. His findings are included in a detailed report on these experiments.

FIG. 11. Gas motor operator mounted on a 30-in. through conduit gate valve. Small lever for controlling operation has three positions; open, neutral, and close. Note small handwheel for operating valve by hand, if necessary. Handwheel drives valve through operator gearing.

Tight seating or torque limit control is, in general, more satisfactory on valves that depend on application of force for leak tight closure, such as various types of gate valves, globe valves, or lift plug valves. Torque seating in both opening and closing directions is desirable for most through conduit gate valves.

Often, combinations of both types of limit control are desirable. For many gate valves, torque or tight seating control is desired for closing and, position control is desired for opening. When torque control is used, valve travel will be stopped if for any reason the gate valve becomes hard to stroke. Where complete travel is desired regardless of the force required, a combination of both types of control in parallel are desirable. Position limit control prevents valve travel from being interrupted until the valve has reached seating position and then allows the valve to be seated tightly by the torque method.

Where protection of the operator and plug valve is the prime consideration, torque control or torque control in series with position control is desired. Valve operation will be stopped by an obstruction in the case of torque control only. With both types of control in series, torque control will protect against excess load on valve and operator. Position control will act to stop the valve operator at the end of valve travel.

Electric motor operators are now available with both torque and position controls, for both opening and closing, and the limit control switches may be used to operate in any manner desired, for any valve or application. Additional contacts are provided for operating indicator lights for remote indication of valve position.

Electric motors for valve operators are designed particularly for valve operating service. They are high speed, high torque, torque rated motors, designed to give maximum work output in the time required to open or close a valve. Although they are not suitable for continuous duty, many will withstand overloaded or even stalled conditions of rather long duration. Motors are usually class "B" protected with glass insulation to permit the use of smaller motors and still prevent damage by high temperatures. Motors are available to operate on various voltages on d-c, and a-c, three phase or single phase service. Bearings are usually of the sealed type, so that little or no maintenance is necessary. They may be constructed so as to meet shock tests when required. Motors for gas pipe line service should be explosion proof.

Other features that may be incorporated in the motor gear drive are: Auxiliary handwheel operation, an automatic or lever operated clutch mechanism to switch from handwheel to motor drive and vice versa, and a lost motion device which first allows the motor to reach a certain speed then engages with a hammer blow effect that uses, in addition to motor torque, the kinetic energy of the rotating motor armature and other parts to unseat the valve and begin driving.

Some manufacturers employ a lever, which when moved by hand, disengages a handwheel drive. When the motor is started the handwheel is desengaged automatically and the motor begins driving the valve. Fig. 9 shows an electric operator of this type. Another manufacturer furnishes a fully automatic clutch that always leaves the handwheel engaged when the motor is not running. It shifts to motor drive after the motor has started without ever moving the handwheel, and returns to handwheel drive before the motor stops without moving the handwheel. If the valve is being operated by the handwheel, the motor drive can begin and stop without endangering the man turning the handwheel. Fig. 10 shows an electric operator of this type.

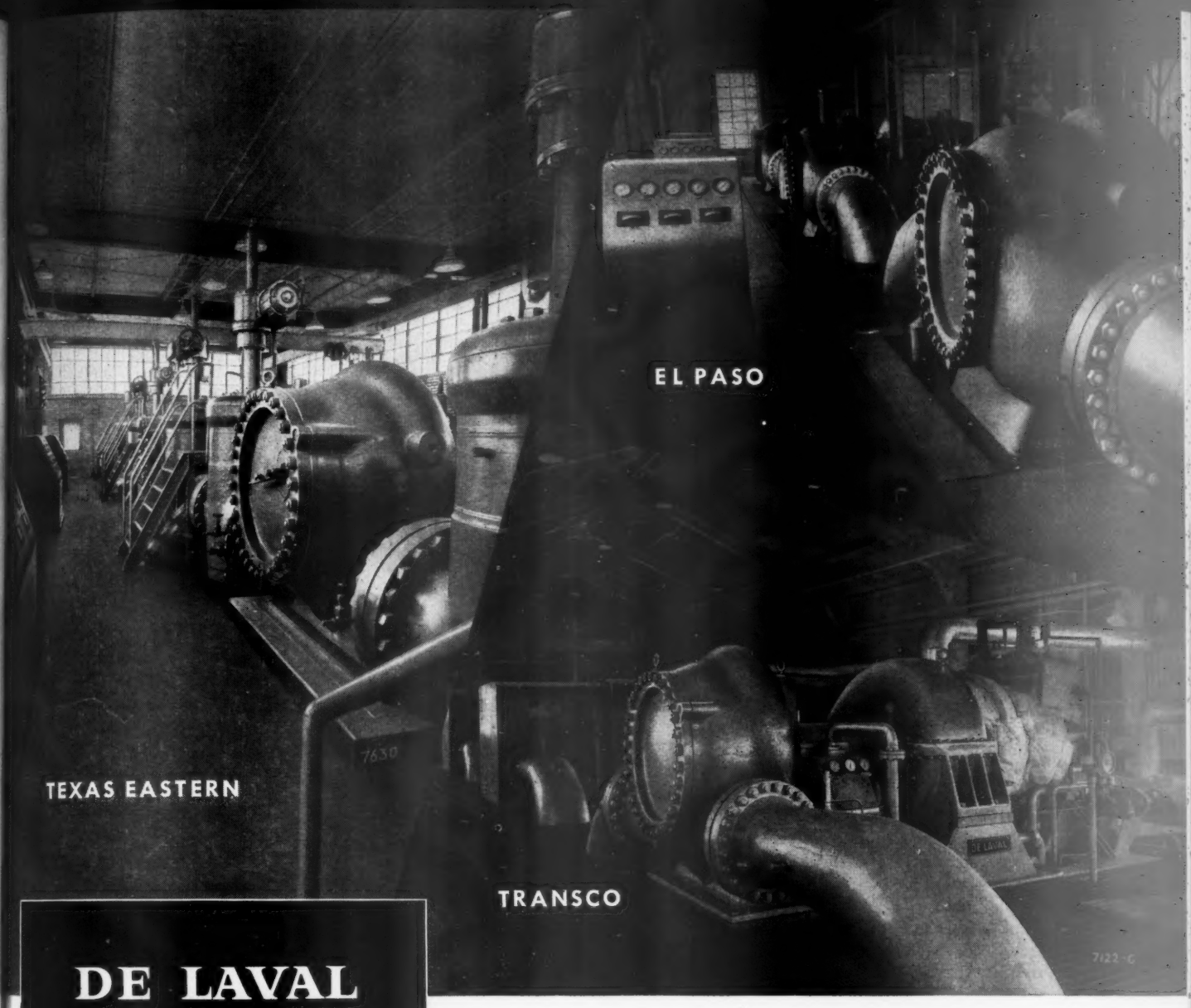
In the case of some large gas pipe line gate valves, handwheel drive through the operator is burdensome because of the large number of turns required for valve operation (possibly 3000 or more). Here, two or more men would be required to spin the wheel almost an hour to operate the larger pipe line valves. When adapting motor operators to such valves it is believed desirable to retain handwheel operation normally furnished with the valve so that handwheel operation will require only 10 or 15 minutes, and if necessary, two or more men may pull on opposite sides of the large wheel. This wheel should be easily detachable so as not to present a hazard during motor operation.

When motor operators are installed on large gate valves for service in pipe lines, it is often desirable to retain the handwheel and have the valve manufacturer supply an extra shaft and flange on the opposite side of the gear housing for mounting the operator. Normal handwheel operation in this manner is not possible with valve operators using a worm drive. Consequently, handwheel operation must be incorporated in the valve operator.

Electric motor operator manufacturers employ various types of mechanisms to provide limit control. For position type of control, a gear limit is popular. It consists of a stack of from two to four small gears, the bottom gear being driven by some part of the gear train that drives the valve. At the end of every revolution of the bottom gear, the gear above turns one tooth and so on. The top gear finally flips a cam that actuates a snap acting switch stopping the motor, after a preset number of turns have been counted.

The principle of operation of most manufacturer's torque limit controls is essentially the same, although details of construction vary. In any case, the essential part is the thrust spring which is compressed as valve seating occurs, and its movement trips a switch that stops the motor, and then this same spring absorbs kinetic energy of the rotating parts until they come to rest. The point in spring movement where a switch is actuated is adjustable to provide the degree of seating tightness desired.

The electric motor operator is started and stopped and direction of rotation



DE LAVAL CENTRIFUGAL COMPRESSORS

do a big job for gas pipelines

High pressure gas transmission on pipelines calls for equipment that's dependable as well as efficient. That's why De Laval centrifugal compressors have been chosen for these and many other booster stations.

De Laval centrifugal compressors offer important engineering features. • Pressure contact shaft seal eliminates gas leakage. • Construction is heavy and rigid throughout. • Units have high load carrying capacity. • They can be designed to handle an increased ultimate flow.

De Laval units, totaling 200,000 hp, are now in operation on major pipelines. De Laval engineers will be glad to give you the benefit of their wide experience in this field.

TRANSCO selected these three De Laval 5,000 hp steam turbine-driven centrifugal compressors for their Tylertown, Mississippi station.

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TEXAS EASTERN—The thirteen 2,500 hp centrifugal compressors on this company's 30-inch gas pipeline from Kosciusko, Mississippi, to Uniontown, Pennsylvania, are all De Laval.

DE LAVAL *Centrifugal Compressors*

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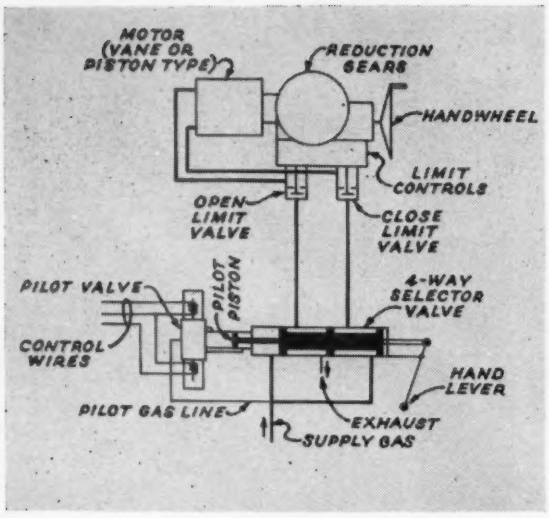


FIG. 12. Flow diagram of a gas motor operator with a double solenoid pilot valve for electric control.

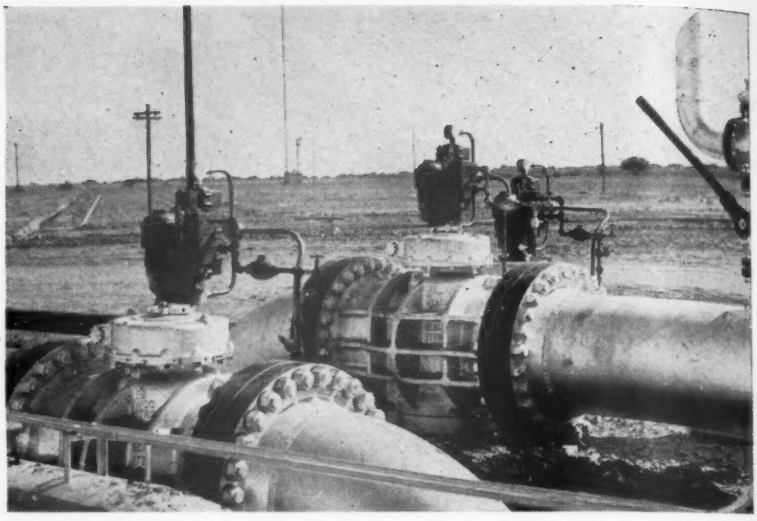


FIG. 13. Gas motor operators mounted on compressor station discharge valves. Solenoid pilot valves, selector valve, limit controls, motor, and reduction gearing are combined into a compact unit.

reversed by a reversing motor starter which is not a part of the operator unit. It consists of two mechanically interlocked contactors, one for opening and the other for closing the valve, and a thermal overload relay. It may also include low voltage protection and a tight seating relay. The motor starter housing depending upon location, may be a general purpose enclosure, dust tight, water tight, weather resisting or explosion proof, as required.

Electric motor operator manufacturers can supply four or more operator frame sizes for adaption to the various sizes and types of valves. Gear ratios and motors for each size may be varied, within limits. Motor torques range from 15 ft-lb or less to 150 ft-lb at 3400 rpm.

One manufacturer's largest machine with 150 ft-lb, 3400 rpm motor can operate a 26-in. series 600 through-conduit gate valve, with 1000 psi differential across the valve in 70 seconds. All sizes of plug valves up to 30-in. series 600 may be operated much faster. Even the larger sizes may be operated in 15 seconds.

High Speed Rotary Type Motor Operators

The pneumatic or gas motor operator has become the most popular operator with several of the major gas companies during the last few years for reasons already mentioned. Two types of rotary motors have been used, the multi-piston type and the multi-vane type. The piston type motor uses several small pistons to drive the motor shaft by means of a crankshaft or wobble plate. A valve or valves is incorporated to admit gas to pistons and exhaust them in sequence.

The piston type motors are usually below 500 psi but motors of this type are also available to be driven by gas at line pressures of 1000 psi or more. Multi-vane type motors are most popular for 1000 psi service where gas is used directly from the pipeline, or from a reservoir at pipe line pressure. These motors operate at speeds ranging from 1000 to 3000 rpm. The speed of operation varying with the load.

A line lubricator is necessary to maintain constant lubrication while the motor is functioning. The lubricator is installed in the gas supply line to the operator. An atomized spray of oil is drawn into the gas stream and all parts in contact with the supply gas are

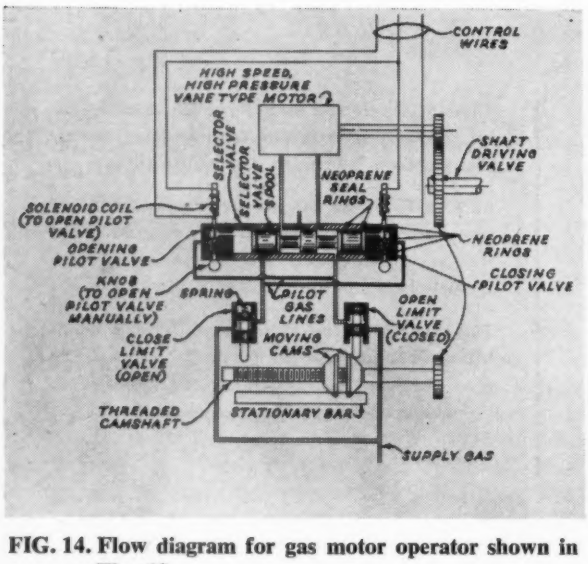


FIG. 14. Flow diagram for gas motor operator shown in Fig. 13.

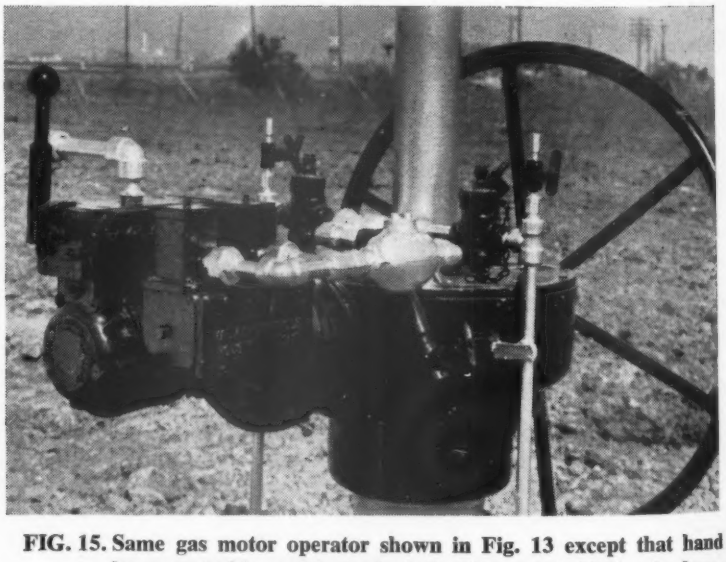


FIG. 15. Same gas motor operator shown in Fig. 13 except that hand lever control is used instead of electric control. Notice the large wheel that drives this 30-in. through conduit gate valve directly rather than through motor operator as shown in Fig. 13.

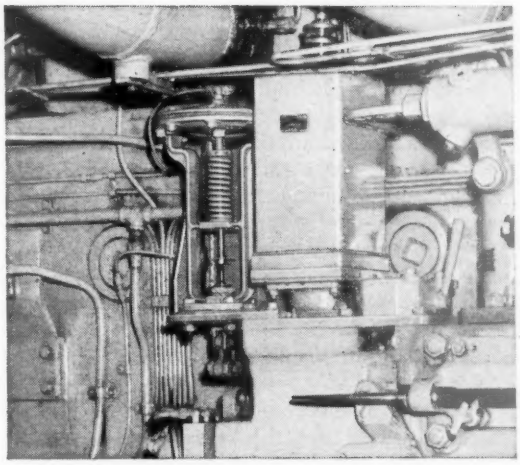
100% PNEUMATIC CONTROL FOR PUMPING STATIONS

DRAWING below shows how a well known Midwestern Pipeline Company controls suction and discharge pressures as well as engine speed pneumatically, with fully automatic Taylor control. Here's why this system was chosen:

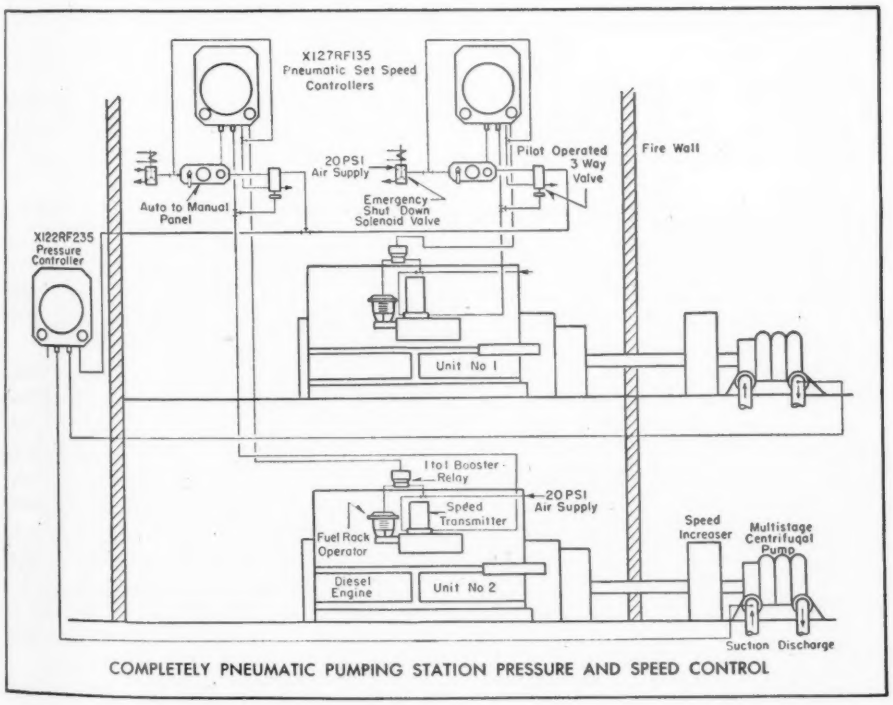
1. High accuracy and rapid response to load changes.
2. Simplicity and dependability of FULSCOPE* control proven in over 15 years of use.
3. Easy to set up and adjust for optimum station performance.
4. Maintenance costs are cut to the bone, since station pressure controllers and speed controllers are same basic instruments.
5. Continuous record of engine speed is available at all times.

Have you a pumping station problem? Call your Taylor Field Engineer or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

*Reg. U.S. Pat. Off.



Close-up view of Taylor Speed Transmitter and pneumatically-operated fuel rack. Speed sensing transmitter converts engine RPM into pneumatic signal which actuates recording speed controller.



COMPLETELY PNEUMATIC PUMPING STATION PRESSURE AND SPEED CONTROL

STATION suction and discharge pressures are controlled and recorded by master controller in main control room. Pressures are set at their limits, and control is at the value dictated by existing pumping conditions. Output of this master controller pneumatically adjusts speed of two diesel engines to maintain constant suction—or discharge—pressure. Pneumatic-set speed controllers position the fuel rack to maintain the required speed.

The speed control system consists of a pneumatic speed transmitter which converts diesel engine RPM into an output air signal going to a recording speed controller. Speed controller output goes through a booster to the pneumatically operated fuel rack positioner to provide fast action in the event of sudden load changes. Automatic to manual units assist in start-up of individual engines, which are started up on manual and then switched over to adjustment by the master controller.

Taylor Instruments MEAN ACCURACY FIRST

thus lubricated. A high pressure filter in the supply gas line is necessary to prevent foreign matter in the supply gas from entering the operator. Small entrained particles will soon cause leakage in limit pilot and selector valves.

Other essential parts of the pneumatic or gas motor operator, other than the motor and gear train, are travel limit valves and cams, a selector valve for starting and reversing motor, and a handwheel or shaft for hand operation.

Two companies using the same hydraulic or multi-vane motor have different design of controls. A cross section of this motor is shown in Fig. 6.

One company has built its gas motor very similar to its electric motor operator. Gearing and limit control mechanisms are the same except that gear limit and torque limit mechanisms trip poppet limit valves to shut off gas flow to the motor rather than switches. A 4-way selector valve with three positions, close, open, and neutral, is used to start and direct gas flow through the motor in the desired direction to open or close the valve.

When the valve becomes fully closed a torque switch trips the "close limit valve" closed and stops the motor. As the valve is being opened, a gear limit trips the "open limit valve" closed stopping the motor. During operation, both limit valves are open. Fig. 11 shows one of these operators mounted on a 30-in. ASA 600 gate valve.

This same operator may also be controlled electrically by adding a double solenoid 4-way pilot valve as shown on flow diagram Fig. 12. Solenoids are mounted at either end of the pilot valve. To cause the motor operator to close the valve, the close solenoid is energized and it shifts the 4-way pilot valve spool. The 4-way pilot valve allows pilot gas at main line pressure to pass through it to one side of a small piston that strokes the main 4-way valve. Supply gas then passes through the 4-way valve to the motor, then through the motor and back through the valve to exhaust to atmosphere.

When the motor has completely closed the valve, the close limit valve, between 4-way valve and motor, shuts off supply gas flow. Both the pilot valve and main 4-way valve are spring centered to neutral off position when not in operation. To open the motor operated valve, the open solenoid is energized, both the pilot and the main 4-way valves are shifted in the opposite direction, and supply gas passes through the motor in the opposite direction until the valve is fully open and the open limit shuts off the supply gas.

One of the major problems in high pressure pnuematic or gas motor operator design and construction is the building of leakproof pilot, limit, and selector valves that will last, and not present a maintenance problem. High pressures make this problem more difficult. Solenoid shut-off valves have been used in the supply gas line ahead of the operator in some cases to provide a leak tight shut-off except when the operator is in operation.

Another company manufactures a gas motor operator that is entirely different from electric operators. Fig. 13 shows a typical installation on a compressor station discharge valve. This is a double solenoid valve for electrical control. Fig. 14 is a flow diagram to illustrate operation.

This machine consists of a vane type motor and reduction gearing to drive the valve. Reduction gearing drives a camshaft with two cams. Cams actuate limit valves, closing one to shut off supply gas to the motor when the valve has closed, and another to shut off the supply gas when the valve has fully opened. A 5-way valve directs gas flow to the motor. This 5-way valve is easily adapted to several methods of control. It may be equipped with a lever for hand operation, (Fig. 15), and spring loaded to the either normally open, normally closed, or neutral off positions or, it may be furnished with solenoid pilot valves for electrical control.

When energized, a solenoid pilot valve admits gas to one end of the 5-way valve spool to shift it. A pilot valve may be provided at one end of the spool and a spring at the other, or it may be equipped with two solenoid piltot valves, one to shift the spool to the open position and another to shift the spool to the closed position. It may be spring centered to the neutral off position or with the spring omitted.

Spring centering allows the valve travel to stop when the energized solenoid is de-energized. If springs are omitted, valve travel will continue to completion after the solenoid is de-energized and remain in that position until the other solenoid is energized. In other words, only momentary energization of a solenoid is necessary for complete valve travel. Solenoid valves are equipped with knobs for local hand operation.

This machine is very compact and is capable of high torque when using high pressure supply gas. External piping and number of working parts required are a minimum. A shaft extension is provided for hand wrench operation.

With 1000 psi operator supply gas, this machine can close a 26-in. series 600 lubricated type plug valve in twelve seconds, and open the valve with 1000 psi differential across the valve in a somewhat greater length of time. When installed on 26-in. series 600 through conduit gate valve the closing time with 1000 psi supply gas is approximately 80 seconds .In this case also, gear ratio is such that the valve can be opened with 1000 psi supply gas when differential across valve is 1000 psi.

Limit control is the position type but throttling of supply gas occurs near the end of valve travel just before limit valve snaps closed, completely shutting off supply gas. Full unthrottled power is then available to begin valve travel in the other direction.

Limit switches may be furnished on the limit valves, to operate indicator lights at some control location, to begin or stop operation of another device, or to be used for interlocking with other circuits. A junction box with terminal strips may be built in to this unit to facilitate electrical connections.

Operation of any of the devices described above cannot be considered foolproof. A frequent regular inspection and maintenance program is necessary to insure operation when emergency arises. It is evident from the descriptions above, that a large investment is represented by the installation of these operators in any of the systems outlined. No return can be expected on this investment if the plant personnel disregards the essentials that make this equipment the safeguard of the pipeline system.

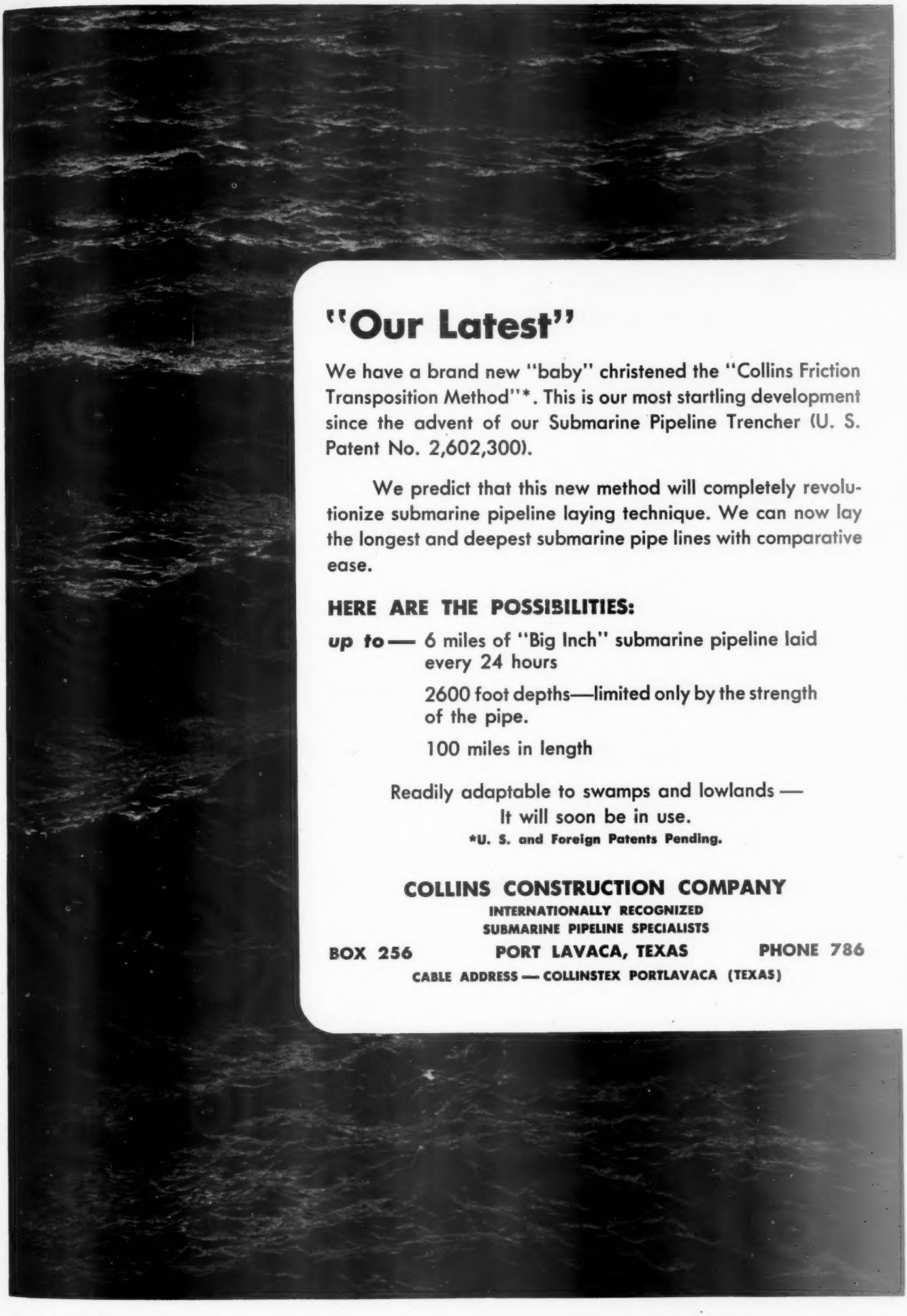
The manufacturer has the responsibility of improving his product so that the equipment he has offered for use represents the best that he can engineer. The pipe line companies have been accepting part of this responsibility by reporting the failures of the equipment and suggesting changes that represent progress in design for reduced maintenance, simplicity and ease of operation of natural gas pipe line systems.

Acknowledgment

The authors wish to acknowledge with thanks the following companies and individuals:

N. F. Blundell of Gulf Interstate Gas Company, *Stephen A. Bergman* of Panhandle Eastern Pipe Line Company; *J. J. King* and *Ben R. Keller* of Tennessee Gas Transmission Company; *Charles W. Beggs* of Public Service Electric and Gas Company; *J. F. Eichelmann* of El Paso Natural Gas Company; *M. J. Paul* of Natural Gas Pipe Line Company of America; *H. L. Stowers* and *W. E. Brown* of Texas Gas Transmission Corporation; *The E. I. M. Company, Inc., Rockwall Manufacturing Company, Philadelphia Gear Works, Inc., Cutler-Hammer, Inc., Cameron Iron Works, Inc., Ledeen Manufacturing Company, and Shafer Valve Company, Inc.* ***

XUM



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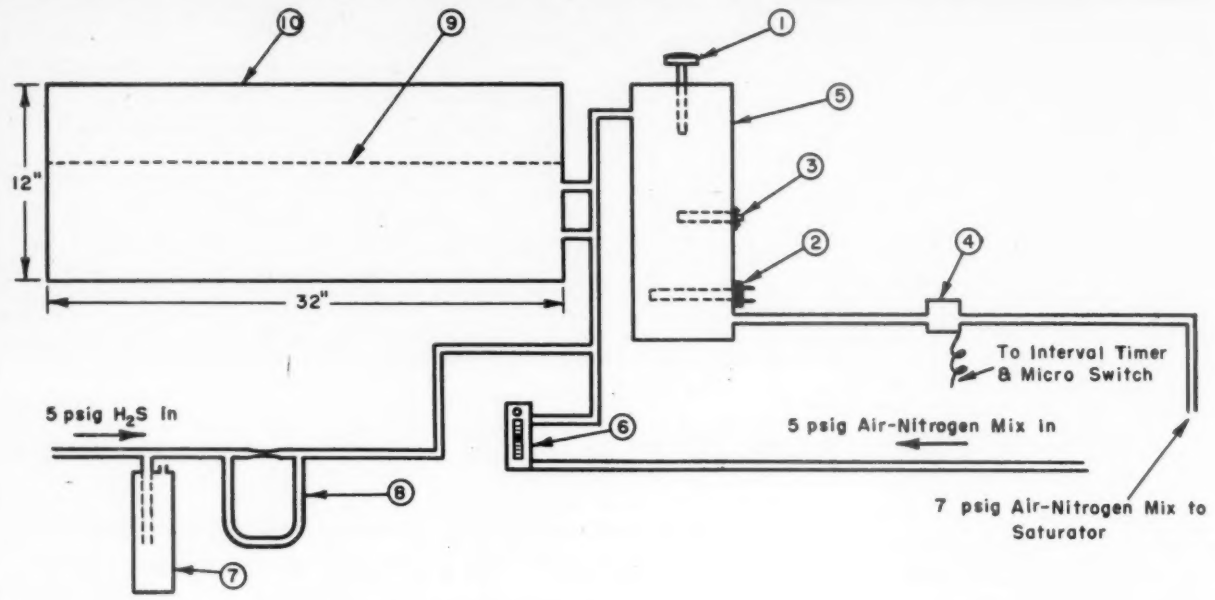

1. Weston Thermometer Model 226 or Similar.
2. 500 Watt, H5V, Chromalox Immerson Heater No. RI-1500, Type 1100.
3. Fenwal Thermoregulator.
4. General Controls Magnetic Valve, Type X-20P Cat. No. 5R413.
5. Saturator Tower Fabricated 6"or8" I.D. Pipe & Insulated.
6. Fischer-Porter Flowrator, C-Clamp, Fig. 130 With Valve Mounted Integrally With Meter.
7. Constant Pressure Head Apparatus-Graduated Cylinder Satisfactory.
8. Orifice For Controlling H_2S Supply to System (glass).
9. Panel Supports.
10. Test Box Proper, 32"L x 24"x12"D Made of Aluminum Sheet.

FIG. 1. Sulfide test cabinet used in testing coatings.

A Major problem that continues to defy solution:

Control of Vapor Zone Corrosion In Sour-Crude Tanks†

Several general methods of control are possible — design, inhibitors, and coatings — but none are completely successful; here's a complete report

A. H. NEWBERG* and J. P. BARRETT**

CORROSION in the vapor space of tanks handling sour crude oil is a major problem. It plagues the producer in lease tanks, the pipeliner in working tanks, and the purchaser and refiner in storage tanks. The problem continues to defy a complete solution even in these days of constant corrosion control backed by extensive research programs. Just five years ago major companies reported that complete tanks had to be replaced after only two years' service. New decks have been reported unsafe after only one year's service. Such reports leave little doubt that serious problems still exist, and large financial losses accrue as a result.

Mechanism of Corrosion

The trouble begins on the underside of the deck where hydrogen sulfide and iron, in the presence of moisture, react to yield iron sulfide and free hydrogen. As iron-sulfide scale begins to accumulate, the trouble is aggravated by galvanic action between this scale and the deck material.

As these reactions progress, the scale builds up to a point where flexing of the deck will cause pieces to break free and fall to the bottom of the tank. Now we have another problem brought about by galvanic action between this scale and the bottom of the tank, which frequently results in deep pitting.

In normal tank operation, considerable air is present in the vapor zone. The oxygen accelerates the total corrosion by introducing oxidation corrosion. The combination of oxygen and hydrogen sulfide causes an extremely aggressive type of attack. The scale build-up is more rapid in this system than in straight hydrogen sulfide, and the depth and frequency of pitting are accelerated.

It becomes apparent, then, that corrosion in the vapor zone is dependent upon hydrogen sulfide, oxygen, and water. Also it is obvious that a large portion of internal bottom corrosion is caused by action on the deck members.

Control Methods

From this brief discussion of the mechanism of attack, several general

*Service Pipe Line Company, Tulsa, Oklahoma.
**Stanolind Oil and Gas Company, Tulsa, Oklahoma.

†Presented at API 34th annual meeting, Division of Transportation, Pipe Line Symposium Chicago, 1954.

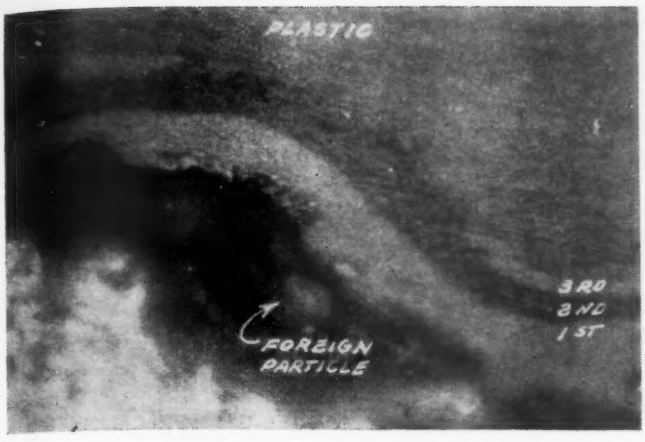

FIG. 2. Visible layers of a 3-coat applied film.

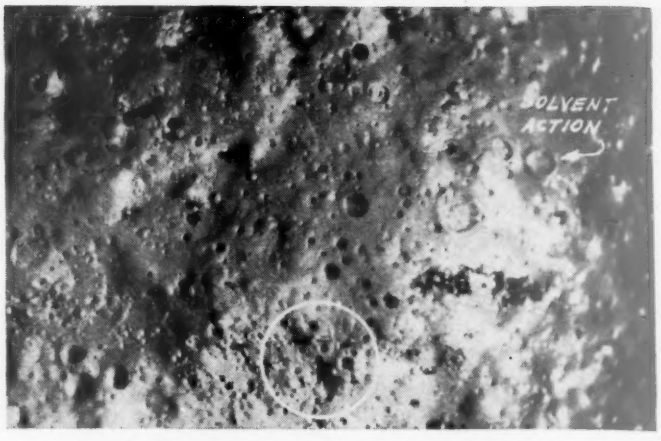

FIG. 3. Surface of the 3 coats applied in Fig. 2.

types of corrosion control become evident. These can be classified broadly into:

1. **Design (including proper selection of materials)**
2. **Inhibitors, and**
3. **Coatings.**

Design is probably the most effective method to combat this attack. The elimination of vapor zone—either in whole or in part—would be the ideal method. The trend to replace cone roofs with floating roofs is a fine example of designing to prevent corrosion. Possible redesign of the shape of internal structure to prevent liquid (water) traps would be economical, either alone or in combination with other methods of prevention. Designs have been suggested to reduce vapor exchange in order to reduce the corrosion rate. To date, these attempts have been disappointing because *complete* exclusion of sulfide is necessary to retard attack.

The use of resistant alloys has been limited by their high cost. In small tanks (500 to 1000-bbl) however, aluminum-alloy decks have been very successful. A new approach recently has received considerable attention. This is the use of rigid, reinforced plastics. Certain of these materials have the strength and other necessary qualifications; however, no long-term data are available to prove their merit.

Inhibitors have been widely used in pipe lines, in production, and in refinery equipment. In these systems the corrosion is generally in the liquid phase, which simplifies the movement of the inhibitor to the corroding surface. Effective inhibitors are found more easily for these systems because we normally deal with only one corrodent. In the past 10 years there has been considerable investigation of the use of gaseous materials as inhibitors for tank vapor-zone corrosion. Although these materials have not been completely successful, they are worthy of more development.

Coatings

The most widely used method of controlling vapor-zone corrosion has been the application of organic coatings, especially in existing structures that have to be converted to sour-crude-oil service. This method holds the promise of elimination of costly redesign and has a low cost (per square foot per year) of steel protected. Inasmuch as coatings are used so widely in this service, it would be well to consider carefully this method of protection.

In order to obtain the most protection for your coating dollar, it is essential that the proper material be selected for the job and that it be applied properly. The proper selection of a coating can be facilitated greatly by laboratory testing.

The effectiveness of a coating system depends upon two main functions, viz.:

1. Its ability to seal the metal from the corroding agent (hydrogen sulfide and water); and,
2. Its ability to inhibit corrosion if the corrodent does permeate the film.

To form an effective seal, a coating must be:

1. Continuous (free of holes or breaks);

2. Impermeable to hydrogen sulfide and water vapor;

3. Adherent to the base metal and co-herent to itself;

4. Chemically inert to hydrolysis, hydrogen sulfide, and oxidation; and

5. Resistant to deterioration from temperature.

The continuity of a coating is a function of its wetting properties. If the coating does not flow on clean metal, a uniform film will not be formed.

Generally, the lower the permeability to water and hydrogen sulfide, the better the corrosion protection afforded. By the addition of pigments the permeability of a resinous vehicle can be changed appreciably. Pigments which are not attacked by hydrogen sulfide should be used.

Adhesion is the bonding of the coating to the base metal. The development of special primers has been very important in obtaining better metal-bonding properties. Cohesion is primarily a property of the coating itself, which denotes the toughness or elasticity of the cured-paint film.

Laboratory Evaluation

The properties of a coating readily can be determined in the laboratory by properly designed tests. All likely materials should be screened by these tests before proceeding with expensive field tests.

A special test cabinet (Fig. 1) can be used to determine readily whether the film is resistant to attack by hydrogen sulfide and whether the film is impervious to the gas. The coated panel is subjected to cycles of moisture condensation and drying while in an atmosphere of hydrogen sulfide and air.

This piece of equipment has been in use for 5 years. The results obtained in this test have been correlated with the same system in field tanks, and it appears that a 24:1 acceleration ratio is obtained.

Standard hydrocarbon-solubility tests are also easily run, as are tests for flexibility and adhesion.

The use of a moisture-vapor transmission test is of great value. In this test the coating film is used to seal a container of calcium-chloride dessicant. The sealed container then is exposed in a constant-humidity cabinet, and the passage of moisture through the coating film is determined by weight increase.

The cost of laboratory testing is only a fraction of that of field testing, and it is disturbing that the major producers of protective coatings have not utilized such test procedures to evaluate their coating for this service. Instead of being offered materials screened by tests of this type, we are urged to use a certain coating because it has given

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good service in coating milk buckets, wine tanks, or cement floors. We have been approached repeatedly by coating salesmen urging us to use materials which, upon laboratory testing, proved to be ineffective in sealing metal from hydrogen sulfide and water.

Application

It should be pointed out that laboratory testing of coatings is designed to test only the coating materials themselves. The very best coating would be ineffective without proper surface preparation and proper application.

The importance of surface preparation cannot be overstressed, particularly where old tanks are concerned. All surfaces must be cleaned of all corrosion products and mill scale, and must be thoroughly dry. Experience has shown that sandblasting is the only satisfactory method for achieving these results. The grain size of the sand is extremely important. A coarse sand will result in deep anchor patterns which require excessive film thickness. According to Liebman,[1] the anchor-pattern depth should not exceed one-third of the total thickness of the entire paint system if a good anchor and optimum film are to be obtained.

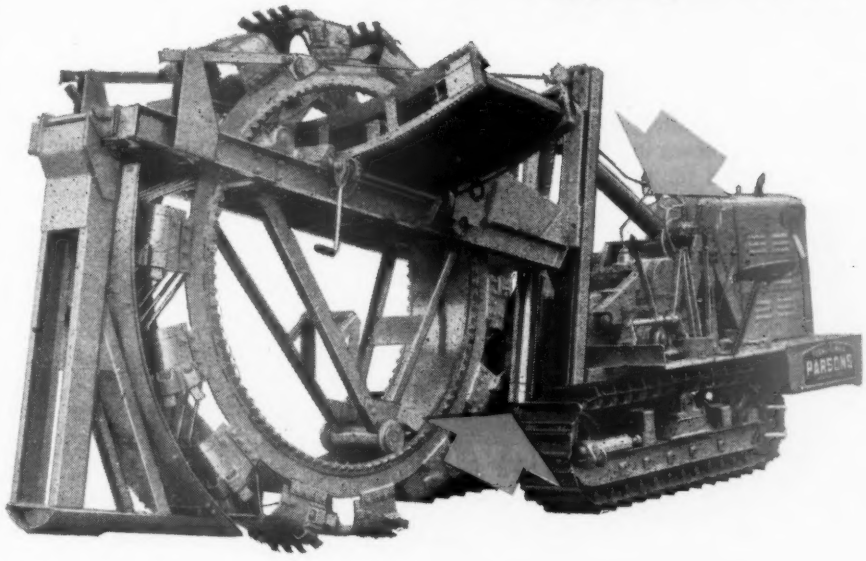
Application of the selected coating material in a uniform and continuous film of the specified thickness requires a high degree of manual skill. In addition, proper equipment must be used and kept in good working order. Competent supervisors and thorough inspection of all phases of the operation are essential.

Spraying techniques are now most widely used in tank vapor-zone coating work. Spray-equipment manufacturers normally offer advisory service on proper nozzle setups, pressures, etc., for spraying any given material. Such service should be utilized fully when a coating operation is being organized. It may seem elementary to offer a word of caution about equipping the spray gun with the proper tip, needle, and air cap for the material being used; however, we have observed operators using siphon nozzles on pressure-type systems and internal atomization where external atomization is required for proper operation.

A supply of clean, dry air is important for spraying. The air receiver on the compressor should be "blown down" at frequent intervals. An extractor also should be used in the supply line to remove oil and moisture from the air. Too often an operator, although not allowed to spray when moisture is on the steel, will, by improper equipment operation, apply considerable water with the paint.

Dry spray, caused in part by holding the gun too far from the work, is a

hydraulic power **raises, lowers, *tilts* the digging wheel**



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Simple mast design on the new 150 Trenchliner eliminates unnecessary superstructure, gives low overhead clearance for work and travel.

30 digging feeds from 12 inches to 25 lineal feet per minute sets a fast pace on pipeline, drainage, irrigation and utility trenching. (Tile box and chute optional.)

8 trench widths range from 16 to 26 inches wide. Maximum digging depth is 5¾ feet.

Quick-change buckets, solid-type or tine-back, are available with gumbo lips or self-sharpening, reversible "Tap-In" teeth for digging dry or wet materials. Buckets are all cast-steel.

Dual-purpose friction clutch drives the digging wheel and serves as an automatic safety to protect machinery against shock loads.

Shiftable, reversible belt conveyor, 24 inches wide, discharges spoil to either side. There are 3 speed selections on the conveyor.

Standard tractor crawlers have 12 or 16-inch treads, lug-type shoes, (street shoes optional). Only 6 or 8 lbs. PSI bearing pressure, depending on tread width.

Gas or diesel power — you have a choice of 58 h.p. gas engine, or 58 h.p. diesel.

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very frequent cause of coating failure. "Arcing" the spray gun has cost operators thousands of dollars in premature failures.

In numerous jobs the exact path of the spray gun can be traced in the failed coating.

Many failures have been contributed to by thinking in number of coats and giving little attention to film thickness. This is shown in Fig. 2. Here the contract called for three coats of material to be applied at a coverage rate specified in square feet per gallon. Three coats can be seen as a gray-black-gray system. Fig. 3 shows the surface of the same system. Upon investigation of this failure, it developed that the manufacturer had given a coverage rate for smooth, nonblasted steel. The coating was applied to pitted, sandblasted metal, however.

The trouble further was aggravated by the excessive thinning required to spread the available material over the greater surface area. Although we repeatedly had obtained 1 to 3 mils per coat with the material in the laboratory at the specified coverage rate, the contractor had obtained a total film thickness in 3 coats of only 0.75 to 2 mils. This same material, properly applied, still is giving protection in several tanks after 5 years.

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You actually get two Pigs in one when you use WILLIAMSON DUBL-DIAMETER PIGS . . . and you'll realize a big saving in manpower and operating costs because fewer scraper traps are needed. These Pigs are designed for efficient cleaning of multiple sizes of pipe and are now in use on oil, products and gas lines of many sizes . . . for instance, a DUBL-DIAMETER Pig regularly scrapes a 50-mile line which consists of 16" and 18" pipe, *including an 8-mile crossing of Galveston Bay.*

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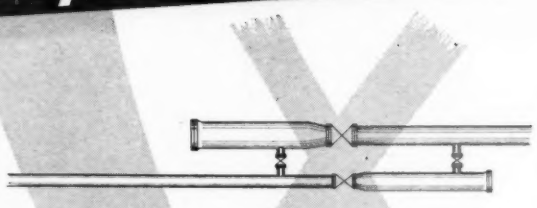
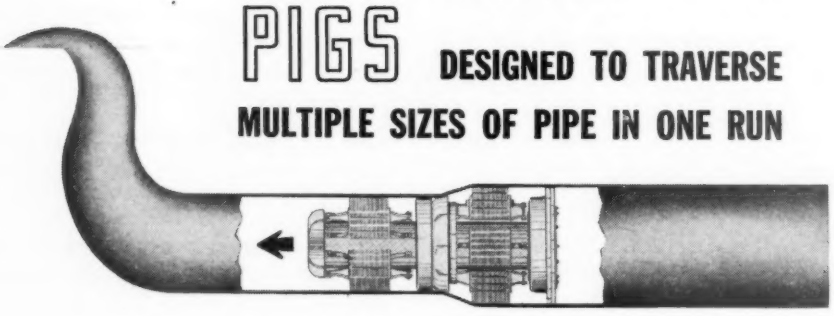


with

ELIMINATES SCRAPER TRAPS WHERE PIPE SIZE CHANGES

DUBL-DIAMETER PIGS DESIGNED TO TRAVERSE MULTIPLE SIZES OF PIPE IN ONE RUN



DUBL-DIAMETER PIGS CONFORM TO THE CHANGES IN PIPE DIAMETER MAINTAINING SEAL FOR CONTINUED PROPULSION

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Roller Coating and Other Methods

The common deficiencies in spraying techniques described herein emphasize the need for improved application methods.

Such methods should assure good control of film thickness and continuity, even when only average manual skill is available for such work. The use of roller coaters offers promise in this respect and should be developed further. Look at the excellent jobs housewives are doing now in applying wall paints with rollers! The principles involved are quite similar.

The use of "hot-spray" equipment is worthy of further development in the application of the newer plastic coatings. This method reduces the material to spreading consistency by heating, as opposed to thinning with solvents. The material thus may have a higher solids' content and a resultant increase in dry-film thickness per coat. Reduction in the use of solvent thinners is desirable because the corroding agent always can enter where the solvent leaves the curing process.

Conclusion

In conclusion, we should like to reemphasize that tank corrosion is extremely costly. Corrosion can be controlled by design, or by use of resistant materials, inhibitors, or coatings—either separately or in combination. No one method has proved completely successful. We believe that considerable progress can be made in the field of inhibitors. Several available materials have shown promise, but are not generally satisfactory at present.

The use of coatings is most attractive economically; however, the manufacturer should be more critical of the materials submitted for use. Rigid inspection of every phase of a coating job by trained inspectors is a necessity for satisfactory performance. The most satisfactory material will not be effective if it is applied improperly. Likewise, a perfect application will not make a poor coating satisfactory.

In an effort to obtain more satisfactory coating jobs, it would seem desirable to direct more research toward the development of both improved application techniques and coating materials having a greater tolerance for imperfect application.

Acknowledgment

The authors wish to acknowledge the assistance of R. M. Carter, tank superintendent, Service Pipe Line Company, in the preparation of the material dealing with coating application.

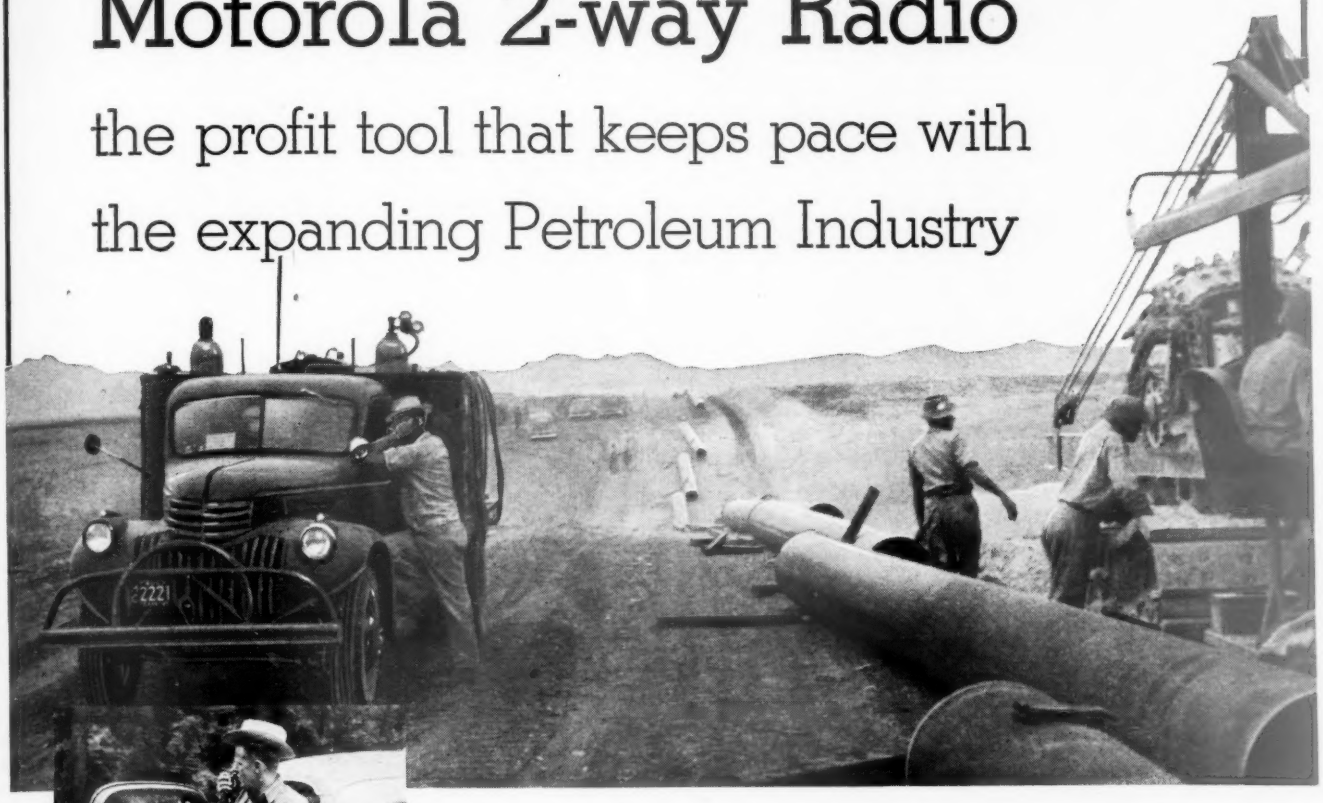
Reference

1. A. J. Liebman, "Surface Preparation Values and Sandblasting Economics," *Corrosion* 6 [5] 151-57 (1950).

* * *

Motorola 2-way Radio

the profit tool that keeps pace with the expanding Petroleum Industry



On a remote strip of pipeline, a road superintendent exchanges some critical information with his spread foreman some 22 miles away saving several hours delay of another complete work unit.

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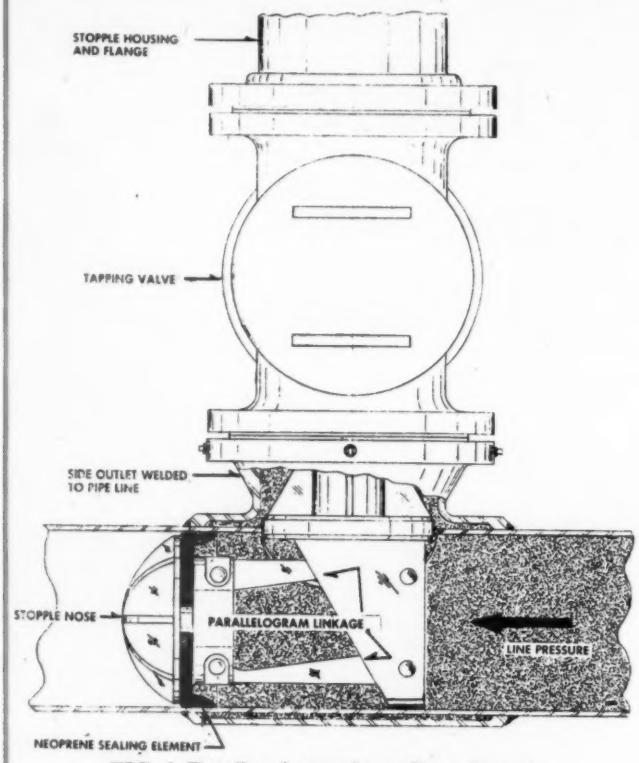


FIG. 1. Details of stopple sealing element.

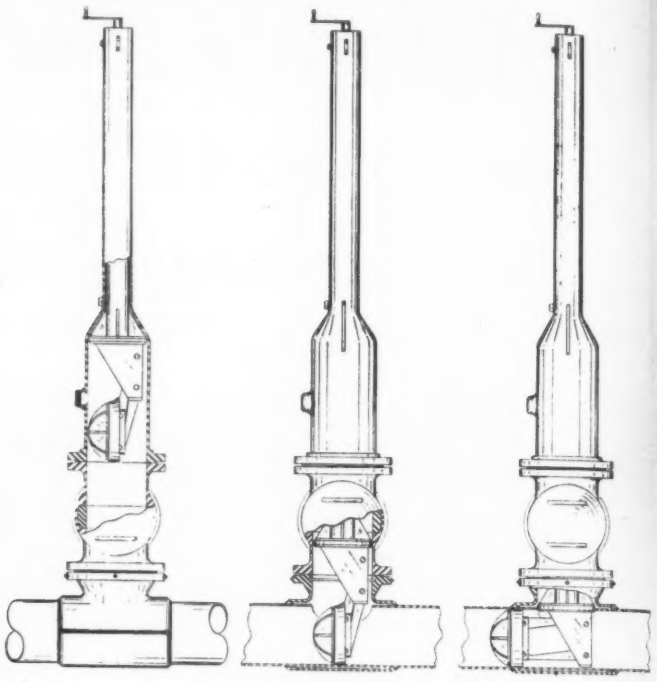


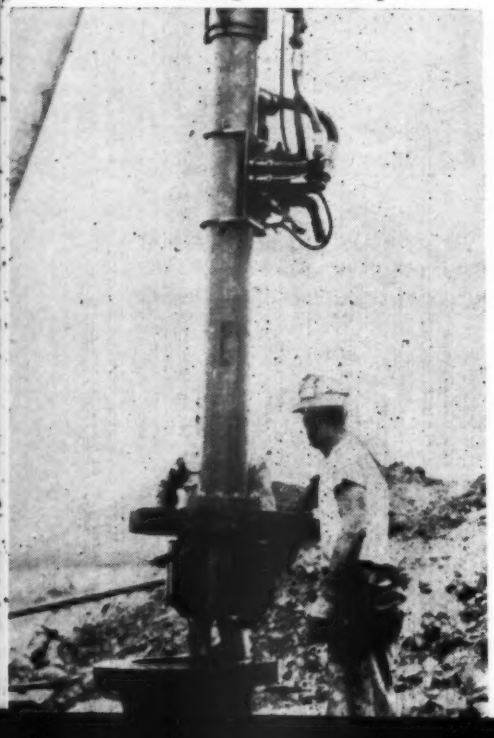
FIG. 2. How unit positions self in line.

Maximum safety, minimum drain, reduced downtime achieved by using high pressure line plugging machine in . . .

Simplifying Block Valve Installation

JAMES H. McBRIEN*

Making 16-in. hot tap.



THE Texas Pipe Line Company found it necessary recently to relocate a section of its 16-in. Corsicana to East Houston, Texas crude oil line. To isolate this part of the line, it was decided that a main line block valve should be installed a short distance upstream. Scheduled oil movements would not permit the usual methods of draining and plugging the line. To minimize shutdown time, it was decided to use a recently developed high pressure line plugging machine called "Stopple."

A point approximately 300 yd west of the Highway 75 crossing near Spring Creek, Texas was chosen for the location of the new block valve because of its accessibility, and its nearness to the relocation work. About 100 ft of line was uncovered by backhoe to allow for plently of working space.

To insert the stopple, a 15 1/16-in. diameter coupon was removed from the top of the line by "hot tapping." This necessitated welding a 16-in. nipple and saddle and setting a 16-in. full opening gate valve. A hydraulically-driven tapping machine was used to make the tap. The actual cutting time required for this operation was approximately one hour and 15 minutes.

The stopple (Fig. 1) consists of a neoprene sealing element similar to a scraper cup that is sandwiched between a heavy metal back-up flange and a guide flange, both slightly smaller than the ID of the line. This element is suspended on the stopple shaft by a parallelogram linkage in such a manner that when cranked into the pipe it moves at right angles to the axis of the valve and away from the tapped hole until it is

*Field representative, Tod Pazdral Company, Houston, Texas.

EXCLUSIVE

FIG. 3. Making a 2-in. tap.

FIG. 4. Main line valve and 2-in. bypass.

completely surrounded by the line to be plugged (Fig. 2). An immediate seal is realized in this position.

During the interval between removing the tapping machine from the valve and bolting the stopple in place, all pumping stations along the line were notified to shut down. In order to minimize their down time, they continued pumping through the completion of the tap.

While the stopple was being cranked into sealing position, a 2-in. internally threaded tapping nipple was welded to the line approximately 2 ft downstream from the stopple, a 2-in. valve was bolted to the nipple, and a small 1 7/16-in. diameter hole cut in the line with a smaller model tapping machine (Fig. 3). This connection served a dual purpose in the job as planned. It provided an air inlet while the section of line downstream from the stopple was drained, and a by-pass connection from the stopple to the few feet of the line between the stopple and the newly-to-be-installed block valve. This afforded a means of equalizing the pressure on both sides of the seal so that it could be easily withdrawn upon completion of the job.

The sealing element was then cranked into final position, and the line was completely plugged off. Suction was put on the section of line downstream from the stopple, and the two inch vent valve opened to admit air. All of the oil from this part of the line was evacuated during the night.

The installation of the block valve, which completed the job, was accomplished the following day. Due to the evacuation of oil downstream from the stopple and an accumulated column of oil upstream, the pressure gage indicated that a differential of 320 psi had built up during the night. Examination through the 2-in. vent valve, however, showed no leakage existed around the seal.

A short section of the line was removed using a mechanical pipe cutter. Mud packs were then placed in the open ends of the line to eliminate the danger of oil fumes, and the block valve was welded in place.

The stopple was removed from the line after first equalizing the pressure on both sides of the seal and utilizing the 2-in. vent valve and by-pass line previously described. (Fig. 4)

The final step was to recover the 2-in. and 16-in. valves through which the work was done. The 2-in. valve was removed by attaching a threaded plug on the boring bar of the smaller tapping machine and screwing it into the internal threaded tapping nipple. The 16-in. valve was recovered in a similar manner, with the exception that the plug in this case was equipped with "O" rings, was locked in the nipple flange by special ring segments, and was installed with the bigger tapping machine (Fig. 5).

After both valves were removed, blind flanges were bolted in their place, all exposed metal was then coated and wrapped and the open ditch was backfilled.

Two important advantages were realized by using the above described technique. By isolating the section of line to be worked on, only a small portion of the line had to be drained, reducing the downtime of the whole line appreciably; and by using a line plugging machine capable of holding back the high pressures involved, the job could be done with complete safety to all personnel involved. * * *

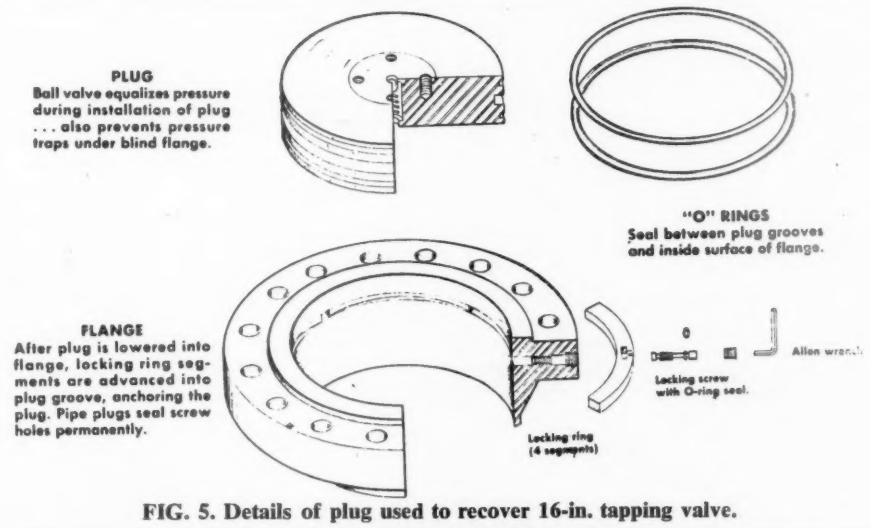

PLUG
Ball valve equalizes pressure during installation of plug . . . also prevents pressure traps under blind flange.
"O" RINGS
Seal between plug grooves and inside surface of flange.
FLANGE
After plug is lowered into flange, locking ring segments are advanced into plug groove, anchoring the plug. Pipe plugs seal screw holes permanently.
Locking ring (4 segments)
Locking screw with O-ring seal.
Allen wrench

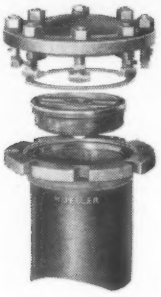
FIG. 5. Details of plug used to recover 16-in. tapping valve.

LINE STOPPER FITTINGS

No-Blo Line Stopper Fittings — welding or mechanical joint type — are used with the "CC" or "C-1" and auxiliary line stopper equipment to stop-off lines to permit repair or replacement without loss of gas or interruption of service. Sizes 3", 4", 6", 8", 10" and 12". Available with series 15, 30, 40, 60 and 90 flanges.

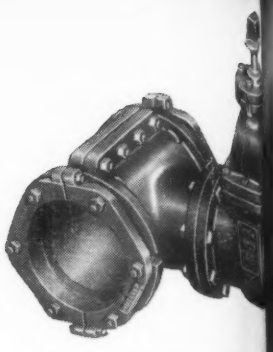
FLANGED TEE

No-Blo Flanged Tees, with welding inlet and outlet and "O" Ring Seal Completion Plugs, are used to make large main connections or run a lateral. Inlet end is contoured to fit pipe one size larger than tee. Sizes 3", 4", 6" and 8". Available with series 15, 30, 40, 60 and 90 flanges.



"SAVE-A-VALVE" DRILLING NIPPLE

No-Blo "Save-A-Valve' Drilling Nipples-used to make temporary connections when it is desirable to recover the valve. Flanged type in sizes 4", 6" and 8". Inlet end contoured to fit pipe one size larger than nipple. Available with series 15, 30, 40, 60 and 90 flanges.

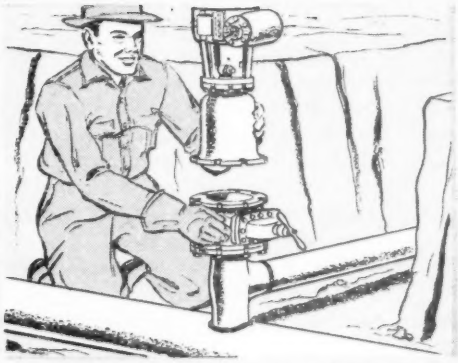


TAPPING SLEEVE AND V

Mueller No-Blo Tapping S and "O" Ring Seal T Valves — regular or mec joint type — are used for m lateral main connections pressure without loss of g interruption of flow in m complete range of sizes.

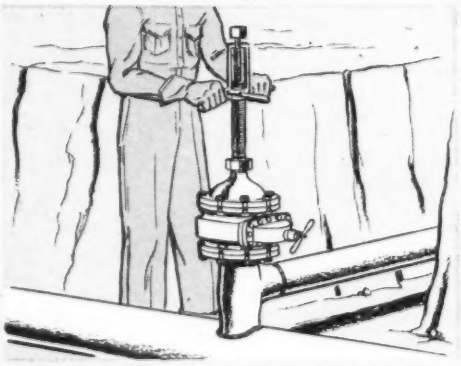
CONNECT LATERAL MAINS SAFELY UNDER PRESSUR

STEP 1. *WELD!* WELD FLANGED TEE FITTING TO MAIN. WELD NEW LATERAL TO OUTLET OF TEE. COMPLETE LATERAL TO FIRST VALVE. TEST. BOLT *MUELLER* GATE VALVE TO FLANGE OF FITTING.



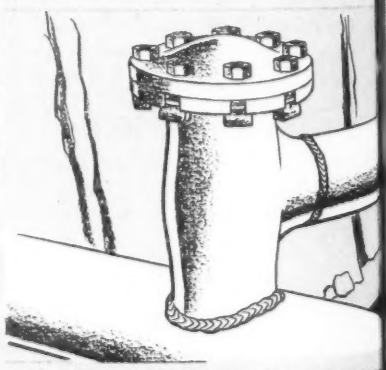
STEP 2. *BOLT!* FASTEN ADAPTER, PILOT DRILL AND SHELL CUTTER TO DRILLING MACHINE. COAT SHELL CUTTER WITH *MUELLER* CUTTING GREASE. OPEN GATE VALVE AND BOLT DRILLING MACHINE TO VALVE.

STEP 3. *CUT!* ADVANCE BORING B UNTIL PILOT DRILL STRIKES MAIN. SET F INDICATOR TO ZERO AND ENGAGE AUTO MATIC FEED. (ATTACH POWER UNIT TO "C-1"). MAKE CUT, RETRACT CUTTER WHICH RETAINS COUPON, CLOSE VAL AND REMOVE DRILLING MACHINE.



STEP 4. *INSERT!* ATTACH COMPLETION PLUG TO THRUST BAR OF COMPLETION MACHINE AND BOLT MACHINE TO GATE VALVE. OPEN VALVE AND INSERT COMPLETION PLUG. REMOVE MACHINE AND VALVE.

STEP 5. *TIGHTEN!* TIGHTEN PLUG SOLIDLY IN TEE WITH SPECIAL WRENCH AND SHORT LENGTH OF PIPE OR ROD. TEST JOINT WITH SOAP SUDS.



STEP 6. *COMPLETE!* PLACE GASKE ON FLANGE AND BOLT COMPLETION CA SOLIDLY IN PLACE. TEE INSTALLATION IS NOW COMPLETE.

MUELLER NO-BLO Method

This is another of a series showing the broad appl tion of Mueller No-Blo Fittings and the mac used for their installation.

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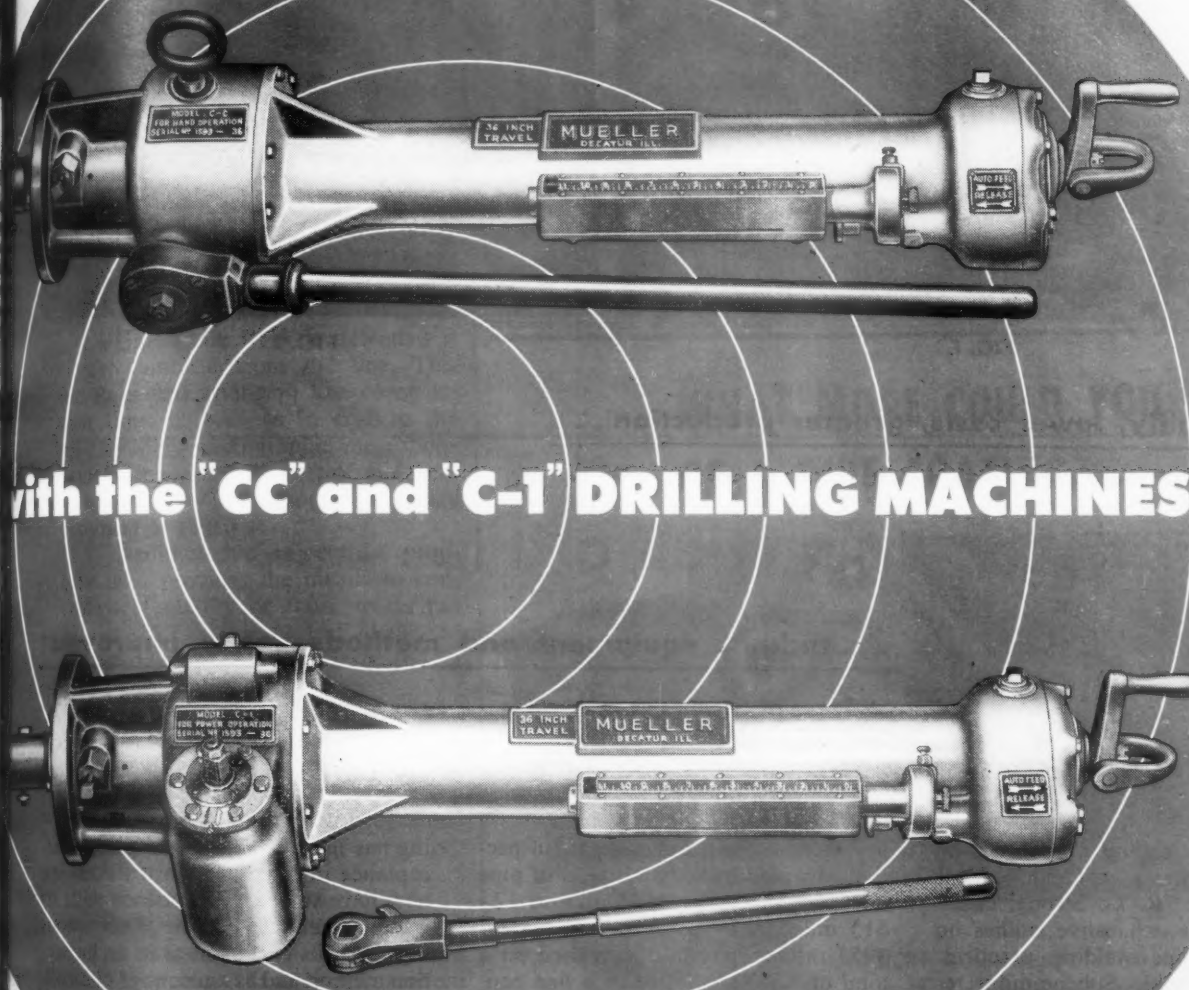
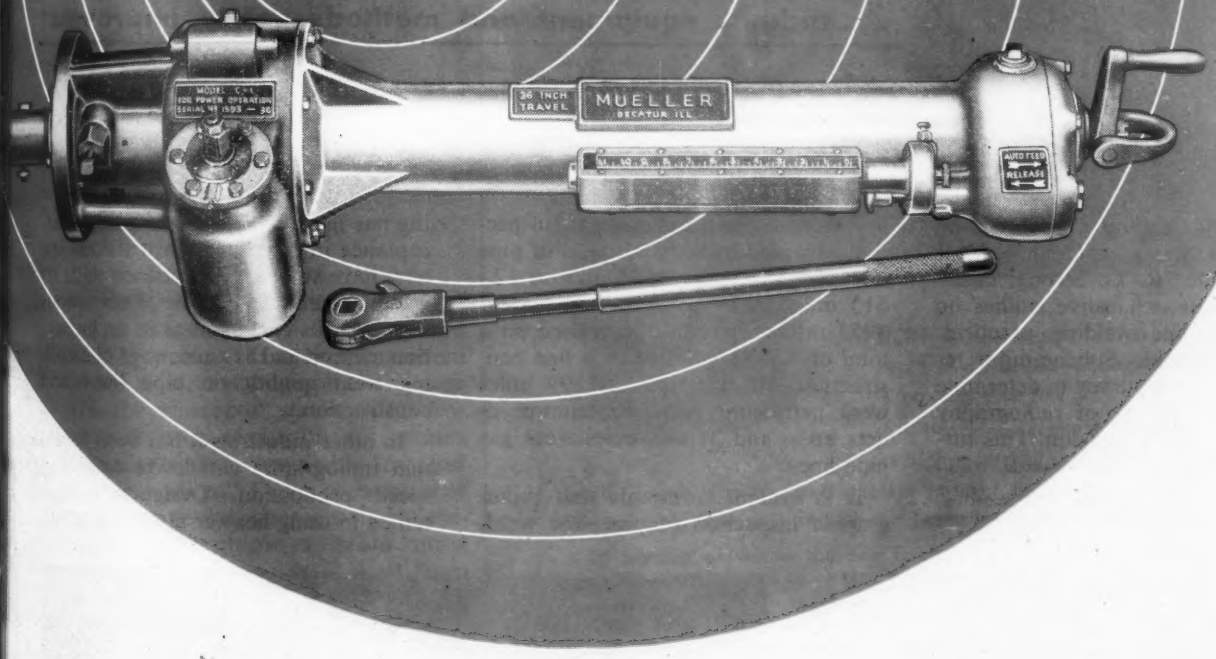


with the "CC" and "C-1" DRILLING MACHINES!



Lateral main connections may be made safely and easily with the Mueller "CC" or "C-1" Drilling Machines and "Save-A-Valve" Drilling Nipples, Flanged Tees, Tapping Sleeves and Valves or any standard gate valve. Both the hand-operated "CC" and the power-operated "C-1" will make cuts from 2" to 12". Tools may be fed manually or automatically. Feed indicators are standard equipment. Boring bar travel is 36". Maximum working pressure is 500 psi at 100°F. Maximum working temperautre is 500°F at 250 psi. Power for the "C-1" is supplied by the H-600 Air Motor or the easily-transportable H-602 Gasoline Engine Drive Unit.

For additional information regarding the "CC" and "C-1" and related No-Blo Fittings, consult your Mueller Representative or write direct.

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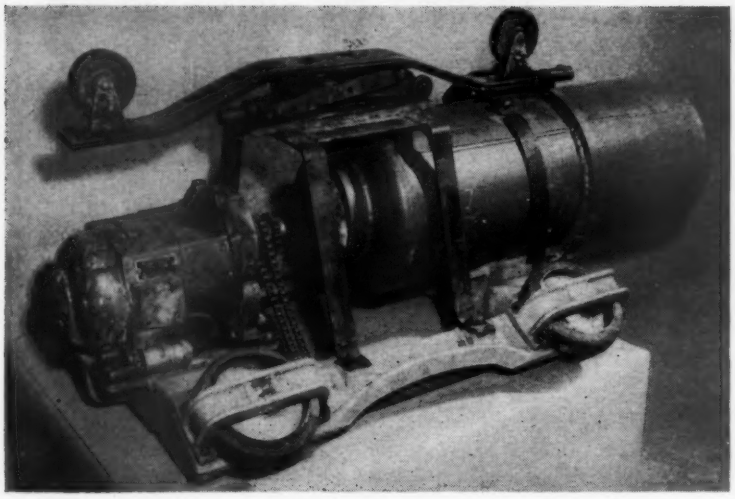

FIG. 1.

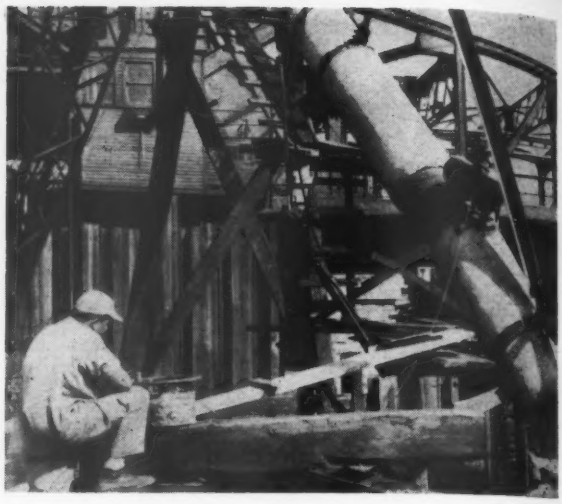

FIG. 2.

Better quality, lower costs, greater production . . .

Radiographic Inspection of Pipe Line Welds

. . . today's equipment and methods vastly improved†

HAROLD HOVLAND*

THE API-AGA Joint Committee on Oil and Gas Pipe Line Field Welding Practices under R. G. Strong, chairman, has made exhaustive studies on current pipe line welding practices. Their Radiographic Subcommitte recently conducted a survey to determine the extent of the use of radiography for pipe line weld inspection. This survey indicated that radiographic inspection was used on only 82 miles of pipe line construction in 1945 and on 12,515 miles in 1953. As of the end of 1953 radiography has been used on a total of 47,884 miles of pipe line construction. Of this total, 16,199 miles were petroleum and petroleum-products lines, and 31,685 miles were gas pipe lines.

It is evident from this that radiographic inspection of pipe line welding has met with wide and general acceptance in pipe line construction. We now have sufficient experience with its use to formulate definite observations regarding its effectiveness as an inspection method and as a means of controlling weld quality on pipe lines and construction.

In other industries it has been found that radiography will lower costs and speed production. Designers accustomed to using heavier plate as a safety

*Industrial X-Ray Engineers, Seattle, Washington.

†Presented at 34th annual API meeting, Division of Transportation, Pipe Line Symposium, Chicago, 1954.

FIG. 3.

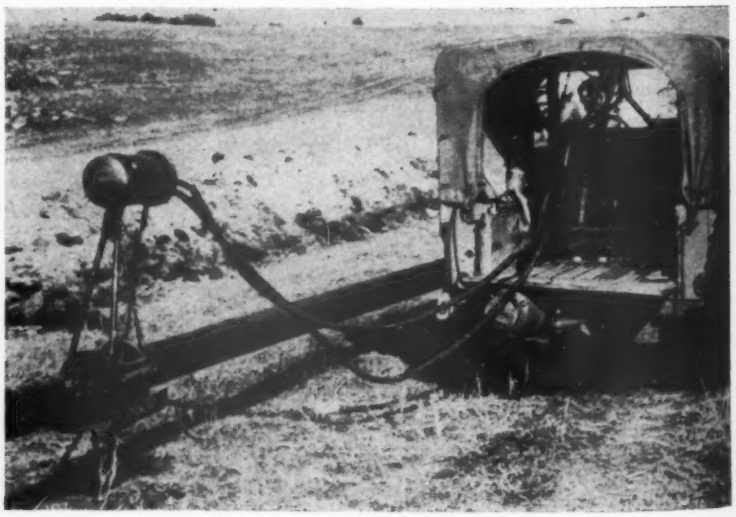

FIG. 4.

XUM

factor have found that by the use of radiography they can control the fabrication and can assure soundness with lighter-weight materials. If used properly there is no doubt that radiography can accomplish the same thing in pipe line construction.

Obviously there must be considerable merit to an inspection method that has been so widely accepted by the industry. Among the factors which attract pipe line engineers to this method of inspection are:

1. It assures a uniformly higher-quality welded joint because it provides inspection with "eyes" to see below the surface and to examine the inner weld structure.
2. Unless the weld is defective it is not removed from the line. This means a real saving in line construction time, as well as in cost to the owner. Many radiographic inspections may be made for the cost of one weld removed. Only the unsound welds are removed or repaired.
3. Radiographic inspection properly used provides the means to control weld quality of those welds not inspected. This means less likelihood of failures and leaks on tests and in subsequent service of the line.
4. The owner is provided with a graphic record of the quality of the field weld, as well as much information on the pipe itself.

Successful use of the radiographic method is dependent upon its proper use.

Selection of Proper Sources

The Handbook of the American Welding Society devotes an excellent section to weld radiography.[1] On page 976 the handbook states: "The low contrast levels obtainable for gamma rays render them unsuitable for most weld inspection." This is so because of the nature of the extremely short penetrating rays obtained from most gamma-ray sources, or at least from those presently available for weld inspection.

On page 10, paragraph 1.721 of API Std 1104: Standard for Field Welding of Pipe Lines[2] there is given a table of maximum X-ray voltages for steel thicknesses to be examined. It is reproduced herein as Table 1.

TABLE 1.
Maximum X-Ray Voltages for Steel Thicknesses to be Examined (from *API Std 1104*)

Total Parent-Metal Thickness (Inches)	Maximum X-Ray Voltage (Kilovolts)
¼ and under	110
⅜ to ⅝, inclusive	130
¾ to ⅞, inclusive	160
¾ to ⅞, inclusive	200
¾ to 1½, inclusive	300

Paragraph 1.724 on page 11 of the same publication gives the voltage equivalents of the presently available radioisotopes. Because in most pipe line work we deal with wall thicknesses of 0.22-in. to 0.50-in., reference to these tables will show why X-ray is indicated as the choice radiographic source on most pipe line work. Table 2 shows this data. If, for instance, one wished to radiograph a pipe wall of a thickness of 9/32-in. to ⅜-in., reference to Table 1 would indicate 130 kv as the maximum kilovoltage to be used. When Table 2 is referred to, it is evident that the use of Cobalt 60, which has a 1200-kv equivalent, is 10 times more penetrating than the maximum which should be used. The use of Cobalt 60 on wall thicknesses of this order results in the production of radiographs of low contrast which lack the ability to reveal fine defects such as cracks. In my opinion such a radiograph is worse than none at all because it is misleading.

TABLE 2.
(from *API Std 1104*)

	Voltage (Kilovolts)	Thickness of Lead (Inches)
X-ray	150 and over	0.005
Iridium 192	200 to 600	0.005
Cobalt 60	1,200	0.020
Radium	800 to 2,300	0.005 to 0.020

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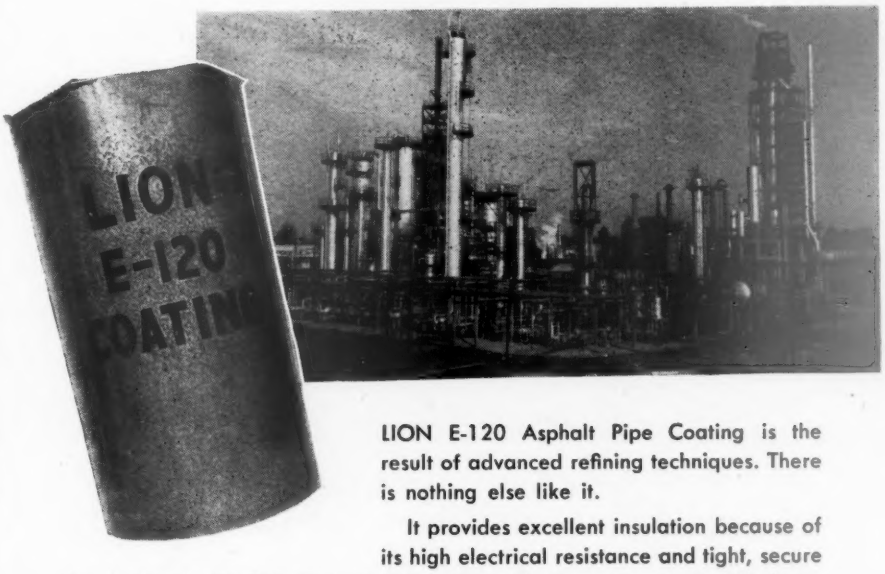

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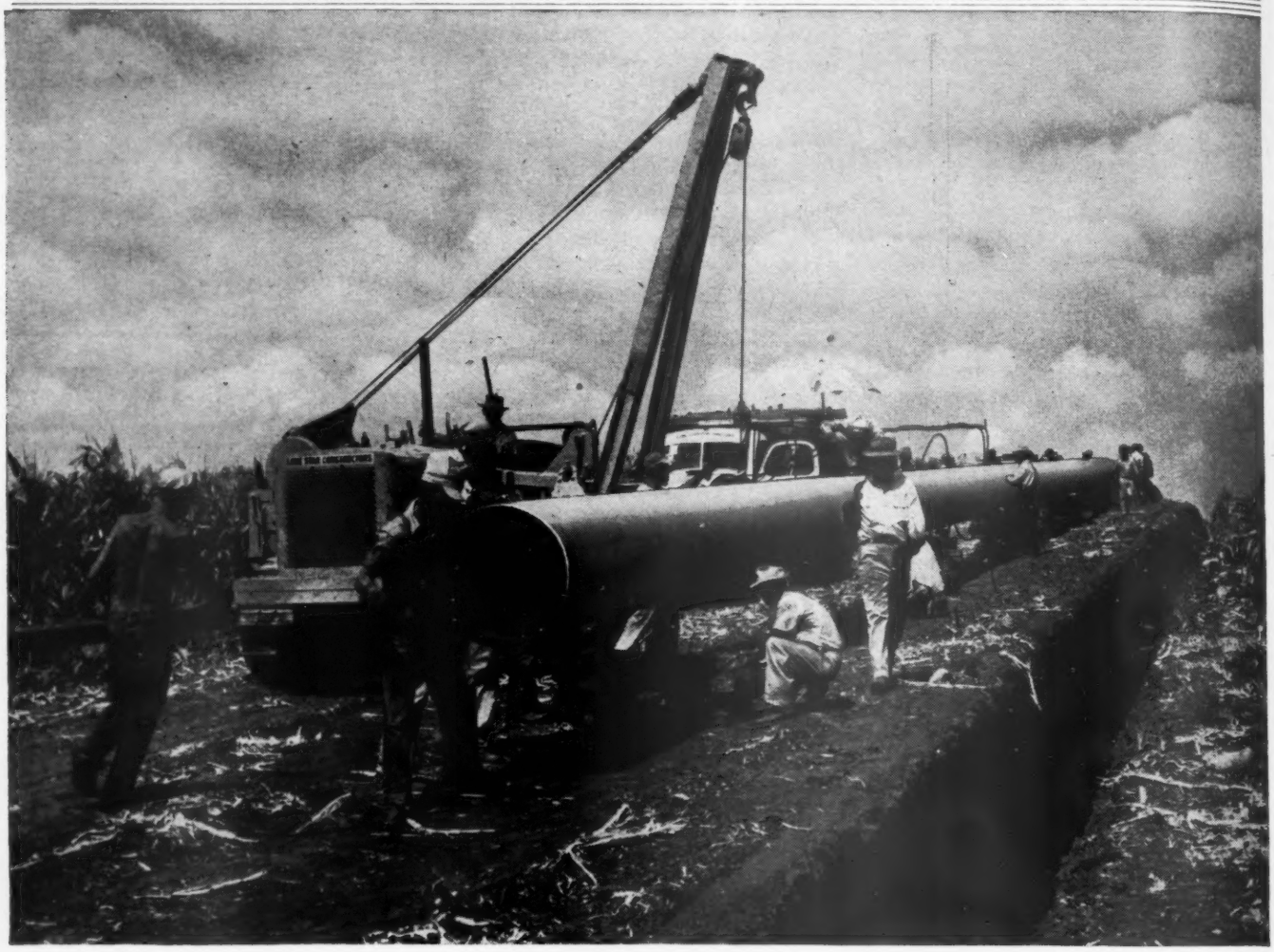
PIPE LINE PROGRESS



Northern Natural achieves billion cu. ft. daily line capacity... builds with A. O. SMITH LINE PIPE

Northern Natural Gas Company this year completes its expanded two-year construction program, with total daily pipe line capacity up to 1,100,000,000 cu. ft. 460 miles of new main line loops were laid in the two-year program, with twelve sections of loop line being laid each year. New line facilities bring natural gas to 71 additional communities in Iowa, Nebraska, Minnesota and South Dakota . . . so that the company now serves a total of 307 communities in the Northern Plains.

A. O. Smith's participation in the job consisted of 178 miles of 30-inch pipe and 60 miles of 20-inch pipe.

Highly regarded in the industry because A. O. Smith welded steel pipe is consistently accurate in size, roundness and end-to-end matchup. A. O. Smith has supplied all or a part of the line pipe for most major pipe lines in the country.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

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The term "radiographic sensitivity" refers to the ability of a given technique to reveal discontinuities or change in density present in the material being examined.

The most serious defects to be coped with in pipe line welding are cracks. This is particularly true with API Std 5LX pipe or other grades in that class. For this reason it is necessary that the radiographic method used have the highest possible "radiographic sensitivity." This should be two per cent or better.

Therefore, we believe X-ray, with which the radiation wave length available can be correctly adjusted to the thickness of steel to be radiographed, is the radiographic source of choice. It has the further advantage of greater radiographic speed which makes the examination more versatile and which enables it to cope with special situations occurring in pipe line construction.

Inspection vs Control

Let us distinguish between weld inspection and welding control. A given weld may be inspected any time after it has been made. If the inspection does not closely follow the fabrication, the information gained from the inspection is of no value for the control of intervening weld quality. Therefore, the inspection is like a "go or no go" gage. Physical tests, because they expose such an infinitesimal portion of the weld, are of little value for weld control. Therefore, the correct way to use radiographic inspection is immediately behind the welding crew. The flow of information between the X-ray crew and the welding crew should be made constant and current.

Pipe line construction is loaded with the human element. Human beings change psychologically and physically from one day to the next. It is as important to have a constant and continuing check on a welder's production from day to day as it is to qualify him originally. Experience shows that more than 50 per cent of all defects in field welds are caused by members of the construction crew other than welders.

Procedural errors caused by improper spacing, improper line-up, movement of the pipe, out-of-round pipe, variations in inside diameter, temperature changes, and changes in the chemical content of the steel are matters that the welder cannot always control. An expert welder could—if his life depended on it—cope with some of these conditions and still produce a good weld. From a practical standpoint, you know they will not. With adequate radiographic inspection, defects caused by these procedural errors will be identified and corrected.

To effectively control the quality of welding, test methods are required that will give us maximum information. A properly made and interpreted radiograph of the weld has the advantage of allowing one to see not just a cross section, but a continuous area. Not only the number and type of defects can be determined from it, but also any trend or tendency of the welder to drift away from correct procedure. In weld control it is important to detect such trends before they result in unacceptable welding.

For instance, a welder frequently will become careless in cleaning slag, unintentionally change the length of his arc, or fail to adjust his machine setting correctly. Originally such carelessness or error may not cause unacceptable welding, but experience shows that, if continued, defects caused thereby usually become more frequent and exaggerated. If not corrected they ultimately result in cutouts or repairs. The trend on a radiograph is a red flag to the radiographer. As soon as one is indicated, successive radiographs of the particular welder's work

▲ Every business has a "fatigue factor" in production efficiency. A man gets tired . . . his work slows down . . . he makes more mistakes . . . and the company loses money! Often without their knowledge, the handling of heavy equipment tires your pipeline welding crew.
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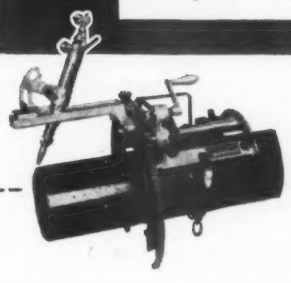
40% Lighter . . . Through an exclusive metal manufacturing process, the H & M Pipe Beveling Machine Company has reduced the weight of their equipment by 40%. The #5 machine, used on 28" to 36" diameter pipe, formerly weighing 155 lbs. now weighs only 95 lbs. and can be easily handled by two men. Weight reductions on other machines are proportionate. For detailed information, write today to: H & M, 311 East 3rd St., Tulsa, Oklahoma.



H & M PIPE BEVELING MACHINE COMPANY

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are examined carefully to determine if the error is continuing. If so, it is called to the inspector's attention immediately.

Much has been written on statistical sampling. There is a great difference in the results of statistical sampling of an automatic manufacturing process, as compared to a project requiring hand welding. For example, in the manufacture of machine screws it has been proved that statistical sampling of a fraction of one per cent is, for all practical purposes, as effective as if each item had been examined individually. But in the case of hand welding on field construction jobs, the quality of the product is entirely dependent upon the vagaries of the human element—not only of the welders but of all the crafts that perform a part of the fabricated product.

To this is added the important factors of weather and construction mechanical problems. For this reason it is believed that the quality of welding is in direct proportion to the percentage of the work tested. It is always good practice, however, at rail, water, and highway crossings, as well as in other critical or congested areas, to have 100 per cent of the welding examined on high-pressure crude-oil product lines.

Most pipe line radiography is primarily quality-control radiography or percentage sampling. Originally, because of equipment limitations, it was fortunate if 10 per cent of the welds in one day, plus 100 per cent of the welding on river crossings could be examined. As the percentage of welds examined is increased, higher weld quality is attained.

Technological improvement in equipment and methods today permits 30 per cent coverage of welding for lower total costs than with 10 per cent coverage in 1946. It should be pointed out that many radiographic techniques allow for the examination of only a portion of a circumferential weld in one exposure. This should be considered when the percentages of the examined welding is being determined. For instance, it is one thing to obtain 25 per cent inspection of 20 per cent of the line welds made, and quite another to get 100 per cent inspection of 20 per cent of the line welds made.

The first petroleum pipe line radiography was done in 1946. We used radium as our radiographic source, inasmuch as there was no equipment portable or rugged enough for pipe line use. It was preferred to have the radiographic source inside the pipe whenever possible because then it is only necessary to penetrate one wall of the pipe, and better radiographic sensitivity is attained. To place the gamma-ray source inside the pipe it was necessary to drill a hole near the weld.

Considerable objection developed to the problems of the hole and the resultant repair required. Today most gamma-ray techniques use the source outside the pipe. With this technique three to four radiographs are necessary to examine one complete weld. The allowable and useful coverage for any given size of pipe, with the source outside, is specified in Table 1.

In 1947 extremely portable X-ray equipment — together with a conduit tractor which propels the X-ray through the pipe—was developed. This permits a single-thickness complete weld coverage in one exposure. With this technique a radiographic sensitivity of approximately 1 per cent can be attained. This equipment will operate in 16-in. diameter pipe and larger. Fig. 1 illustrates a conduit tractor and X-ray unit. On river crossings or with double-jointing procedures this equipment can be used on pipe diameters as small as 12 in. It still is necessary, however, to radiograph tie-in welds and most pumping-station welds from the outside. These weld examinations, whether X-ray or gamma-ray, should be made in accordance with Table 1. Fig. 2 illustrates a tie-in weld being

The time you save today is the money you make tomorrow.

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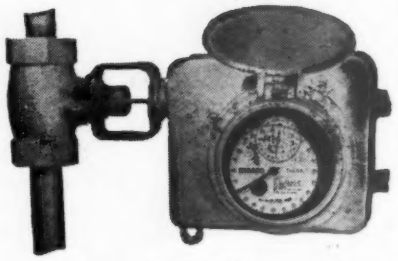

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Enardo has developed another time and money saver called the model "W" clock shut-off valve. It is designed to control the flow of pressures up to 100 PSI of gas or liquid, and to shut off the supply at a pre-determined time. It is particularly adaptable for use on fuel lines to engines. The model "W" clock is manually set and has the same "run-time" as the above models.

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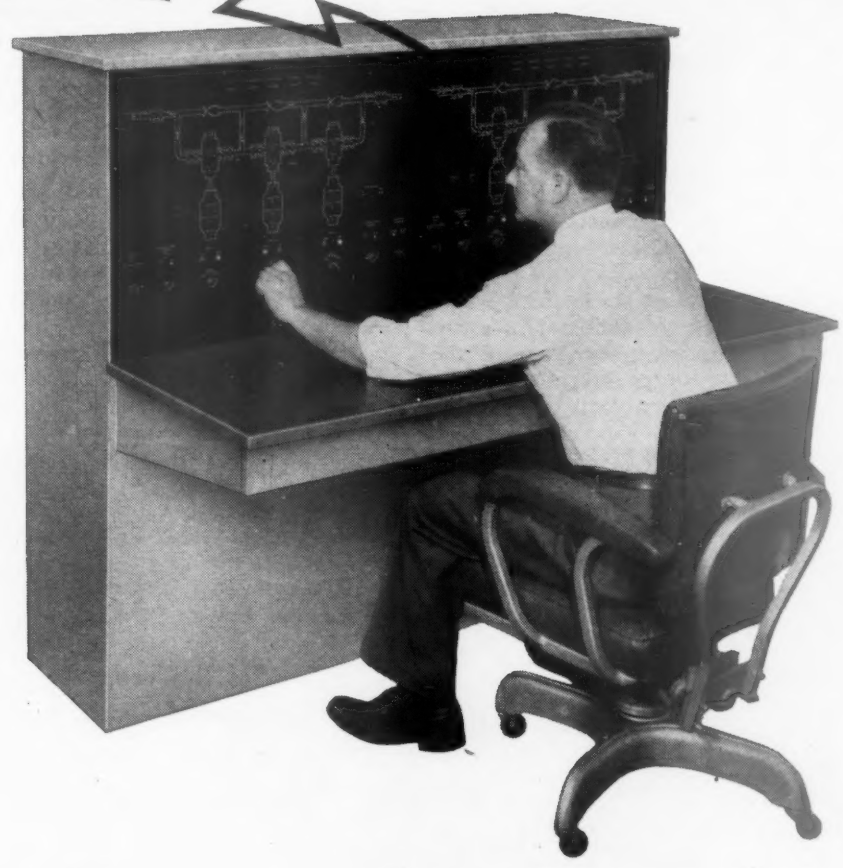

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examined with the X-ray source on the outside of the pipe.

Pipe line welds less than 16-in. diameter usually are radiographed from the outside. Pipe line welds 10 in. and smaller are radiographed in elliptical projection. This provides complete weld coverage in 2 exposures taken at 90 deg. (Fig. 3.)

Pipe welds on river crossings are radiographed 100 per cent. Offsetting the cost of radiography is the fact that rarely are welding sleeves used where 100 per cent weld radiography is employed. Usually on barge work the radiographic source is kept inside the pipe and is controlled by a cable through the line-up clamp. As each weld is completed, it is radiographed and the film is processed while the joint is being coated. Thus, if the weld is acceptable, the only delay for the crew is the 2 to 5 min required for the X-ray exposure. (Fig. 4.)

Operator Qualifications

If the radiographic method is to be successful in attaining good inspection in the control of weld quality, it is necessary to have qualified and competent radiographic operators. Much pipe line radiography has been performed by personnel not qualified for the job by either experience or training. Pipe line owners should employ standardized qualification tests for each radiographic operator, just as they do for their pipe line welders. Such tests should include the following:

1. There should be proof that the operator has a basic understanding of the radiation with which he is working.
2. Actual test exposures should be made in the exact manner that is proposed for line-weld radiographs and on weld coupons similar to the line pipe. The test radiographs should be checked carefully by the inspector against the line-weld radiographs to make sure that radiographic quality is maintained.
3. The operator's procedure should be checked for radiation safety. Radiographic operators should be required to wear radiation badges monitored by a recognized testing laboratory.
4. There should be proof that the operator has experience and knowledge of pipe line welding procedures.

With the widespread use of radiographic inspection on pipe line work it is important that owners not only obtain the proper type of radiography, but also that radiographic personnel be qualified in their duties to the end that other workers and the public are protected from radiation hazards.

Radiographic Costs

In discussing radiographic costs it is understood that, all other factors remaining the same, they will vary according to geographic location and weather conditions of the job. Most radiographic contractors work on a daily basic fee, plus so much per radiograph or weld examined.

In 1948 a 10-in. petroleum line costing $23,650 per mile had 9.35 per cent of the welds radiographically examined for $122.22 per mile, or .023 cent per foot of right-of-way.

The cost per weld examined was $8.30. Radiographic inspection represented one-half of one per cent of the line cost.

In 1949 and 1950 an 8-in. products line cost $17,569 per mile for construction. A gamma-ray source was employed for radiographic inspection with the source being outside the pipe. From 25 to 30 per cent of each weld was radiographically examined; 9.75 per cent of the welds were so examined at a cost of $70.12 per mile. The cost per radiograph representing one-third of the weld was $9.30. The cost per foot of right-of-way was .013 cent.

In 1950 10 per cent of all welds on a 10-in. products line were completely examined at a cost of .02 cent per foot of right-of-way, or $9.15 per foot of complete weld examined. In 1950 it was necessary to use the outside-exposure technique on lines 20 in. and

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smaller. A 20-in. petroleum line was so examined at a cost of $4.38 for one-third weld exposure.

Improvements in technique and equipment have made possible a greatly increased percentage of radiographic tests for the same amount of dollars. For example, today the X-ray with conduit tractor can be used on pipe diameters of 16-in. and larger. Generally speaking, the cost per foot of right-of-way for X-raying 10 per cent of the welds is .0189 cent. For 20 per cent it is .0284 cent. For 30 per cent coverage it is .0331 cent. These estimates are based on the average construction rate of about one mile per day.

When radiographic inspection is considered, it is management's problem to determine whether 10, 20, or 30 per cent inspection is desired. Naturally this point will be influenced by pipe size and by engineering and safety considerations. It is the writer's considered opinion that on larger-diameter lines 30 per cent weld inspection is the best buy for the owner.

A radiographic contractor has a basic fixed cost of operation in any one operation. Therefore, it is obvious that the fewer the welds examined, the higher will be the cost per weld. From experience we know that the owner buys a much better pipe line for very little in additional dollars when a greater percentage of the welds is examined.

When one considers the cost of cutting out joints for inspection and their subsequent replacement cost, the amount represented goes a long way toward paying for radiographic testing. It should be recognized that under the old system it was necessary for contractors to estimate and charge for cutouts they probably would have to make. This is a hidden charge not often considered when the costs of the two methods of inspection are compared.

There have been many instances in which the costs of the welds cut out and replaced by the old method of inspection would have more than paid 30 per cent radiographic inspection and weld control, even though these costs were buried in the contractor's price to the customer. The true X-ray costs should be considered as a differential between the old costs and the new method.

References

1. *Welding Handbook*, 3rd edn., 970-90, American Welding Socy., New York (1950).
2. *API Std 1104: Standard for Field Welding of Pipe Lines*, 2nd edn., American Petroleum Inst., Washington, D. C., Feb. (1954).

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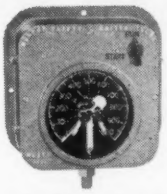

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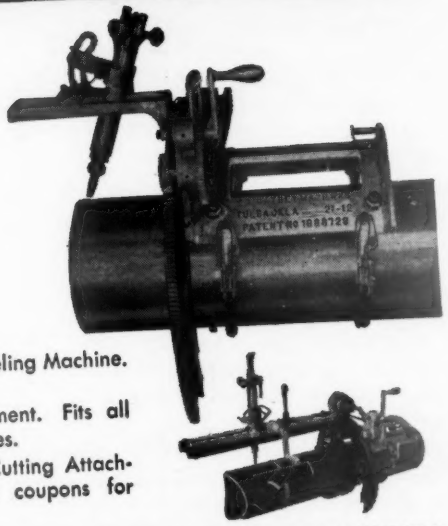

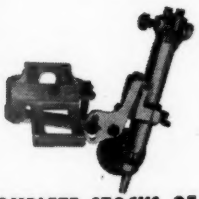

Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

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Design data of 1914 still reliable for crude line design

Pressure Loss in Oil Pipe Lines†

W. L. KENNEDY, JR.*

THE subcommittee on pipe line hydraulics of the API has been assigned the project of accumulating data to indicate the relationship between actual and theoretical flow in large-diameter pipe lines. This investigation was developed and directed toward the evaluation of design criteria that have been successfully used for several years in predicting the flow rate and pressure-loss of smaller diameter lines. Fluid-flow characteristics or pressure loss data were in most cases obtained under measured and controlled conditions. The results should be applicable for design purposes.

Fifteen companies operating large-diameter lines participated and submitted test data. Several of these companies submitted data for more than one line or for different flow rates through the same line. In all, data for 58 flow conditions were obtained in 36 different sections of pipe line varying in diameter from 12 to 31-in. By supplementing these data with those available from other sources, we believe we obtained sufficient information between Reynolds numbers of 40,000 and 250,000 to arrive at a sound conclusion for flow conditions in large-diameter crude-oil pipe lines.

Three products pipe line companies participated. Because of the lack of data for large-diameter products lines, this report is confined primarily to crude-oil lines. Data submitted on products lines, however, will be shown, for comparative purposes, along with data derived from crude oil lines.

Location

The geographical distribution of the lines tested is widespread. Twelve states (Louisiana, Mississippi, Texas, Oklahoma, California, Maine, Georgia, Kansas, Missouri, Illinois, Indiana, and Iowa) and two foreign countries (Canada and Saudi Arabia) are represented. Lines, when tested, had been in service from 3 weeks to 14 years, and are used to transport from 1 to 6 grades of crude.

Pipe

Diameters of the crude-oil pipe lines ranged from 12 to 31 in. Test conditions were reported on one 12-in., three 16-in., six 18-in., thirteen 20-in., seven 22-in., seven 24-in., four 26-in., and one 31-in. lines.

The lengths of sections tested varied from 7 to 176 miles. Most section lengths were between 38 and 110 miles.

Most of the pipe was electric welded. The rest was seamless. All traverse joints were welded by electric arc.

There was a slight change in inside diameter of pipe in several of the test sections. This necessitated conversion to an equivalent length representative of the majority of the pipe in the particular section. In practically all cases, the inside diameter differences were only small fractions. The noted exception was where 30-in. pipe, which represented more than 50 per cent of the section was converted to 31-in. pipe.

Scrapers

Scrapers were run within one week before the tests in about two-thirds of the lines. In most of the remaining lines scrapers had been run within 3½ months preceding the tests. The frequency of running scrapers varied from one per week to one every three or four months. Experience with paraffin deposits and the consequent reduced flow or an increase in pressure determined and regulated scraper frequency.

TABLE 1.

Comparison of friction factors — Stanton and Pennell data vs. test data

Company	Location of line	Crude in line	Date of test	Date last scraper run	Years line in service	Eq. length in miles and size	Rate of flow b/hr.	Calculated Reynolds No. "R"	Calculated Friction factor "F"
Mid-Valley Pipe Line Company	Louisiana & Mississippi	West Texas	2–15–53	2–13–53	2.50	54.6—20″	8217	223794	0.01518
West Texas Gulf Pipe Line Company	Texas	West Texas	7–13–53	7– 6–53	0.50	67.2—26″	13108	247017	0.01424
	Texas	West Texas	7–13–53	7– 6–53	0.50	67.2—26″	12568	236841	0.01467
	Texas	West Texas	7–13–53	7– 6–53	0.50	67.2—26″	11656	219655	0.01492
Pan American Pipe Line Company	Texas	West Texas	10– 2–53	2– –53	0.75	7.4—26″	7595	185954	0.01605
Trans-Arabian Pipe Line Company	Saudi Arabia	Arabian	6(13–19)53	Not run	2.50	201.3—31″	13765	174000	0.01610
Service Pipe Line Company	Oklahoma	West Texas	7–15–53	5–15–53	2–7	70.7—20″	6376	258200	0.01473
	Oklahoma	West Texas	7–22–53	7–15–53	2–7	70.7—20″	6250	253100	0.01472
	Oklahoma	West Texas	10–14–53	7–15–53	2–7	70.7—20″	6040	230790	0.01541
Interprovincial Pipe Line Company	Canada	Redwater	5(15–19)53	5– 7–53	3.00	109.9—20″	6520	51330	0.02055
	Canada	Redwater	5(15–19)53	5– 7–53	3.00	109.8—20″	6686	52110	0.02020
	Canada	Redwater	5(15–19)53	5– 7–53	3.00	116.9—20″	6588	53200	0.02070
	Canada	Redwater	5(15–19)53	5– 7–53	3.00	103.9—20″	6520	53080	0.02040
Standard Oil Company (California)	California	San Joaquin	5– 2–53	4–15–53	8.00	77.7—18″	4633	68800	0.01960
Magnolia Pipe Line Company	Texas	M.C.	12– 1–53	11–24–53	0.10	155.0—16″	2171	46819	0.02087
	Texas	W.T.—M.C.	11–16–53	11–10–53	5.00	83.4—20″	4868	90904	0.01753
	Texas	W.T.	11–16–53	11–10–53	5.00	83.4—20″	4551	84455	0.01834
Portland Pipe Line Company	Maine	W. Tarra	1– 5–53	12–31–52	3.00	39.4—18″	5436	70958	0.01919
	Maine	Hy. Ofic.	7– 2–53	6–17–53	3.00	39.4—18″	5485	59243	0.01956
	Maine	Oficina	7–25–53	6–17–53	3.00	39.4—18″	5457	80322	0.01859
Humble Pipe Line Company	Texas	Hawkins	12– 3–53	None	0.67	21.8—16″	2140	4462	0.03677
	Texas	Hawkins	12– 4–53	None	0.67	21.8—16″	3219	5896	0.03600
	Texas	West Texas	12– 1–53	9– 1–53	3.50	78.9—18″	2846	36887	0.02136
	Texas	WestTexas	12– 1–53	9– 1–53	3.50	78.9—18″	3504	50386	0.02033
	Texas	West Texas	4–19–48	1– 1–48	0.33	39.4—20″	4752	232646	0.01591
	Texas	Panhandle	4–22–48	1– 1–48	0.33	39.4—20″	7075	105111	0.01831
	Texas	South Texas	4–23–48	1– 1–48	0.33	39.4—20″	7000	274030	0.01678
Sinclair Pipe Line Company	Missouri	M.C. & Wyo.	7–21–53	7–17–53	0.50	32.4—22″	4990	76796	0.01730
	Missouri	M.C. & Wyo.	7–22–53	7–17–53	0.50	88.9—22″	5026	73498	0.01860
	Illinois	M.C. & Wyo.	7–22–53	7–20–53	0.50	33.6—22″	5131	71259	0.01870
	Illinois	M.C. & Wyo.	7–27–53	7–23–53	0.50	162.1—22″	5793	80312	0.01870
	Illinois	M.C. & Wyo.	7–24–53	6–19–53	0.50	21.7—22″	4762	60139	0.01960
	Illinois	M.C. & Wyo.	7–26–53	6–19–53	0.50	85.4—22″	5676	79630	0.01980
	Illinois	M.C. & Wyo.	7–26–53	6–19–53	0.50	85.4—22″	4280	60045	0.02090
	Oklahoma	M.C.	7–13–53	7– 2–53	0.50	7.0—24″	3741	57660	0.02670
	Oklahoma	M.C.	7–13–53	7– 2–53	0.50	26.8—24″	3769	58107	0.02160
	Oklahoma	M.C.	7–14–53	7– 2–53	0.50	90.1—24″	3757	55783	0.02070
	Kansas	M.C.	7–16–53	7– 7–53	0.50	20.5—24″	4746	71698	0.01820
	Kansas	M.C.	7–16–53	7– 7–53	0.50	59.7—24″	4716	70511	0.01910
	Kansas	M.C.	7–17–53	7– 9–53	0.50	16.0—24″	5459	78198	0.02410
	Kansas	M.C.	7–17–53	7– 9–53	0.50	46.6—24″	5546	80659	0.01970
Sohio Pipe Line Company	Indiana	M.C. & Ill.	7– 1–54	6–21–54	14.00	43.2—12″	3182	87700	0.01860
			Products						
Plantation Pipe Line Company	Georgia	Diesel Fuel	9–19–53	7–10–53	3.00	54.2—14″	3594	187803	0.01590
	Georgia	Gasoline	9–30–53	9–28–53	3.00	46.5—18″	6007	876752	0.01190
Great Lakes Pipe Line Company	Oklahoma & Kansas	Gasoline	4–26–53	3–23–51	3.00	49.0—12″	3838	844000	0.01091
Standard Oil Company (Indiana)	Missouri	Gasoline	6–12–54	6– 1–54	1.50	96.9—12″	935	260400	0.01390
	Missouri	Gasoline	6–12–54	6– 4–54	1.50	104.6—12″	935	260400	0.01410
	Iowa	Gasoline	6–12–64	5–27–54	1.50	102.1—12″	935	260400	0.01630

*Service Pipe Line Company, Tulsa, Oklahoma.

†Presented at API 34th annual meeting, Chicago, Division of Transportation, pipe line symposium, November 9, 1954.

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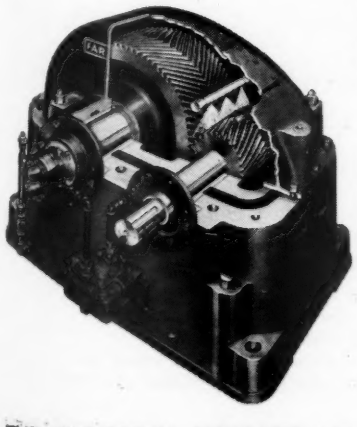

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Flow

Flow rates varied from about 2000 bbl per hour in 16-in. lines to more than 13,000 bbl per hour in the 26 and 31-in. lines.

Tank gages were used in practically every case to determine the rate of flow. Test intervals ranged from 30 min to 1 week; however, most were within the 1 to 4-hour range.

Pressure

Differential pressures corrected for elevation differences are within a range of 11 psi to 1122 psi. Because of the various lengths of line involved, a more suitable means of expressing pressure is pounds per square inch drop per mile. These pressures varied between 1.57 psi and 13.25 psi, with most of them between 4 and 12 psi. There was no correlation between pounds per square inch drop per mile and the size of line.

The discharge pressures were controlled and recorded automatically during the tests. Instruments of high accuracy, properly checked and calibrated, were supposed to be used. Notations indicate in most cases that both discharge and suction pressures were stabilized for several minutes before the beginning of the tests.

Crude Oil Characteristics

All tests were made when one type of crude oil or a mixture of similar crude oils completely filled the test section during the entire period of testing. Domestic crude oils were South Texas, North Texas, East Texas, Oklahoma, Kansas, Wyoming, and California (San Joaquin-Waxy). Foreign crude oils were Arabian-Stabilized, and Canadian (Redwater).

Viscosity and gravity determinations were made from samples withdrawn from the line during the test period. Whenever stabilized crude oils were being handled, or whenever previous testing had established the physical characteristics of the oil fairly well, samples were not taken.

The viscosity range was rather narrow. Most values were from 40 sec to 60 sec (Saybolt Universal). Only 2 tests involved crude oil having a viscosity greater than 80 sec. (Saybolt Universal). These values were between 300 and 400 sec (Saybolt Universal), and the line tested was 16 in. in diameter.

Temperature

Average temperatures of the streams were from 47 F to 106 F. The majority were between 50 F and 80 F, which is indicative of average annual and summer temperatures.

Temperature variations were very small at the initial and terminal ends of the test sections. Variations, however, were from 0 to 7 F between the initial and terminal end. The one exception had variations as high as 15 F. In this particular case the crude oil was to cool engines while passing through the station.

Equipment

Driver and pump equipment was divided farily evenly between diesel centrifugals, electric centrifugals, diesel reciprocating, and electric reciprocating. Closed-line operation was the method employed in most test sections, and discharge pressure was controlled automatically.

Data

Table 1 is a summary of general information and the results of the tests, and shows company involved, location of pipe line, crude oil in the pipe line at the time of test, date test was performed, date last scraper was run, years line has been in service, size and equivalent length of line, and rate of flow.

The results of the tests upon which

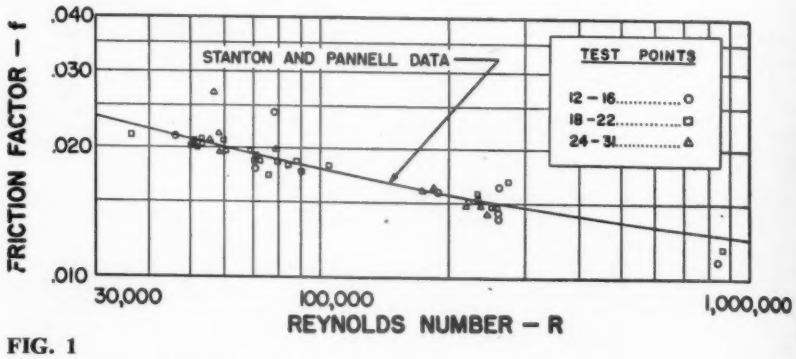

FIG. 1

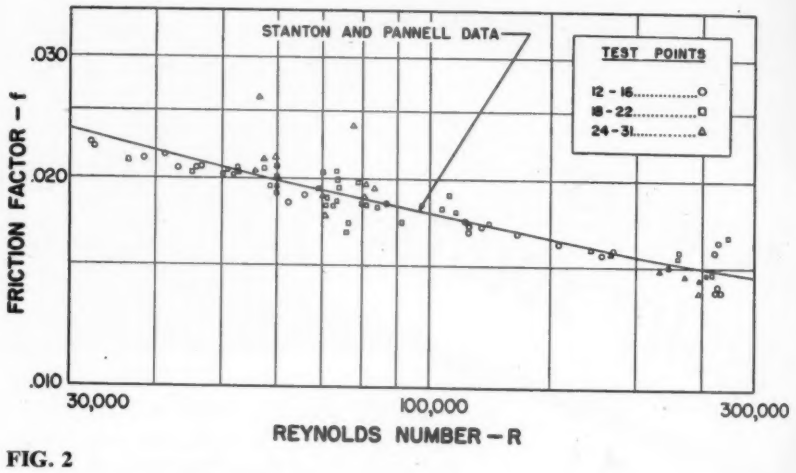

FIG. 2

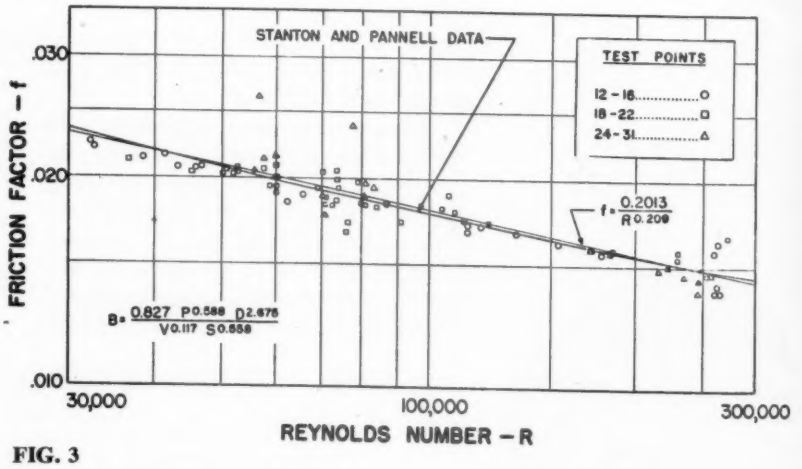

FIG. 3

FIG. 1. Test points compared to Stanton and Pannell data.

FIG. 2. Test and supplemental test points compared to data.

FIG. 3. Straight-line relationship between friction factor and Reynolds number for turbulent flow, based upon Stanton and Pannell curve, where:

B = line throughput, bbl per hour
P = pressure drop, psi per mile
D = inside diameter, inches
V = kinematic viscosity, centistokes
S = specific gravity of liquid pumped

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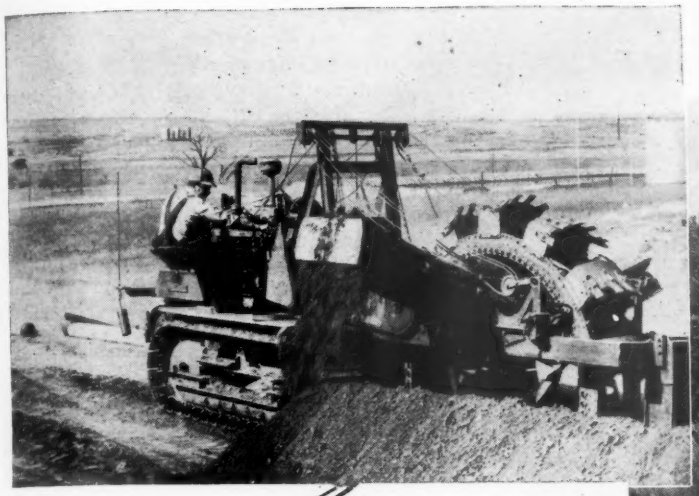

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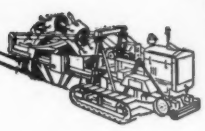

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evaluation of design for larger diameter lines is based are "Reynolds number" and "friction factor." These are computed values derived from known conditions which exist (such as length of line, size of line, and elevation difference at ends of the test section) measured values obtained during the testing operations (such as suction and discharge pressure, rate of flow, viscosity, and gravity of crude oil or petroleum product).

The results of Stanton and Pannell's experimental work published in 1914 are used to compare these data.[1] Stanton and Pannell experimented with air and water flowing at different rates through smooth drawn brass pipe of different diameters. Their work has been confirmed by later experiments on different fluids. Results of tests conducted on crude oil lines in the 1920's on 6 to 12-in. pipe coincided very closely with Stanton and Pannell's data.[2]

The Stanton and Pannell relationship of coefficient of friction or friction factor to Reynolds number is shown by Fig. 1. Also shown are test points for 16, 18, 20, 22, 24, 26, and 31-in. pipe lines as supplied by participating companies in the friction-loss tests.

Supplemental data were obtained for 16, 20, and 30-in. pipe lines. The plotting of these additional points is shown in Fig 2. Practically all points correspond very well to Stanton and Pannell's data within this range. The two 24-in. points at Reynolds numbers of 57,000 and 78,000 involved short test sections, thereby reducing the accuracy of the tests when comparable measuring devices for longer test sections are used.

The variation band of Stanton and Pannell's data is about 2 per cent each side of the mean curve. Actual operating variation is greater than this as indicated by the tests. The number of people involved, the different methods employed, and the common problems of obtaining reliable viscosity data, coupled with the fact that these tests were run by the various operating companies, precludes finer corroboration than that obtained.

From data obtained it is not possible to say that a relationship exists between friction factor and size of pipe. We would assume that the relative roughness effect, and consequently the friction factor, would decrease with an increase in the pipe diameter.[3] As we expect this effect to be negligible, however, in larger diameter pipe, this difference would be so small we would not expect to detect it in tests such as these.

In Table 2 are shown calculated Reynolds numbers and friction factors as derived from the tests performed. These are the same values as were

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TABLE 2.

Company	Size	Rate of flow bbl/hr.	Calculated Reynolds No. "R"	Calculated Friction factor "F"	Stanton-Pannell "F"	Calculated percentage Pr. of design
Mid-Valley Pipe Line Company	20"	8217	223794	0.01518	0.0153	99.2
West Texas Gulf Pipe Line Company	26"	13108	247017	0.01424	0.0151	94.3
	26"	12568	236841	0.01467	0.0152	96.5
	26"	11656	219655	0.01492	0.0154	96.9
Pan American Pipe Line Company	26"	7595	185954	0.01605	0.0158	101.6
Trans-Arabian Pipe Line Company	31"	13765	174000	0.01610	0.0160	100.6
Service Pipe Line Company	20"	6376	258200	0.01473	0.0149	98.9
	20"	6250	253100	0.01472	0.0150	98.1
	20"	6040	230790	0.01541	0.0153	100.7
nterprovincial Pipe Line Company	20"	6520	51330	0.02055	0.0207	99.3
	20"	6686	52110	0.02020	0.0206	98.1
	20"	6588	53200	0.02070	0.0205	101.0
	20"	6520	53080	0.02040	0.0205	99.5
Standard Oil Company (California)	18"	4633	68800	0.01960	0.0194	101.0
Magnolia Pipe Line Company	16"	2171	46819	0.02087	0.0212	98.4
	20"	4868	90904	0.01753	0.0183	95.8
	20"	4551	84455	0.01834	0.0185	99.1
Portland Pipe Line Company	18"	5436	70958	0.01919	0.0192	100.0
	18"	5485	59243	0.01956	0.0200	97.8
	18"	5457	80322	0.01859	0.0188	98.9
Humble Pipe Line Company	16"	2140	4462	0.03677	0.0402	91.5
	16"	3219	5896	0.03600	0.0370	97.3
	18"	2846	36887	0.02136	0.0224	95.4
	18"	3504	50386	0.02033	0.0208	97.7
	20"	4752	232646	0.01591	0.0152	104.7
	20"	7075	105111	0.01831	0.0178	102.9
	20"	7000	274030	0.01678	0.0148	113.4
Sinclair Pipe Line Company	22"	4990	76796	0.01730	0.0190	91.1
	22"	5026	73498	0.01860	0.0191	97.4
	22"	5131	71259	0.01870	0.0192	97.4
	22"	5793	80312	0.01870	0.0188	99.5
	22"	4762	60139	0.01960	0.0199	98.5
	22"	5676	79630	0.01980	0.0188	105.3
	22"	4280	60045	0.02090	0.0199	105.0
	24"	3741	57660	0.02670	0.0201	132.8
	24"	3769	58107	0.02160	0.0201	107.5
	24"	3757	55783	0.02070	0.0203	102.0
	24"	4746	71698	0.01820	0.0192	94.8
	24"	4716	70511	0.01910	0.0193	99.0
	24"	5459	78198	0.02410	0.0189	127.5
	24"	5546	80659	0.01970	0.0188	104.8
Sohio Pipe Line Company	12"	3182	87700	0.01860	0.0185	100.5
Products						
Plantation Pipe Line Company	14"	3594	187803	0.01590	0.0158	100.7
	18"	6007	876752	0.01190	0.0126	94.4
Great Lakes Pipe Line Company	12"	3838	844000	0.01091	0.0127	85.9
Standard Oil Company (Indiana)	12"	935	260400	0.01390	0.0150	92.7
	12"	935	260400	0.01410	0.0150	94.0
	12"	935	260400	0.01630	0.0150	108.7

shown in Table 1. Also friction factor values selected from Stanton and Fannell's curve for corresponding Reynolds numbers are shown for comparison. Based on Stanton and Pannell's curve as design, pressure losses for corresponding flow rates expressed as a percentage of design are shown in the right-hand column.

There is not a direct relationship between friction and Reynolds number for the turbulent flow region. This has resulted in the development of many formulas. The lack of agreement is that developers select different points as well as different ranges on the Stanton and Pannell curve, or other friction factor curves, for the establishment of a direct relationship between friction factor and Reynolds number.

A formula has been developed that covers the range of operation experienced in these tests. The direct Reynolds number—friction factor relationship was established, as shown in Fig. 3, by drawing a straight line between points on the Stanton and Pannell curve corresponding to 40,000 and 250,000 Reynolds number. By writing an equation for this line and substituting in other hydraulic formulas, the formula shown in Fig. 3 was derived.

This formula has little practical use because of its limited range. It was developed purely to reflect the operating conditions encountered in this investigation. Its use is especially limited in the lower Reynolds number range, commonly encountered in smaller diameter pipe in crude oil service, and in the very high Reynolds number range, such as gasoline lines.

Conclusion

Data collected in this investigation of larger diameter pipe in crude-oil service further corroborates the results of Stanton and Pannell in the higher Reynolds-number range. Therefore, design of crude oil pipe lines, particularly 6-in. and larger, based on data of Stanton and Pannell should be sound and reliable.

In addition, it is believed that products lines, 6-in. and larger, operating at much higher Reynolds numbers further will substantiate Stanton and Pannell's data, provided their original internal smoothness has been maintained. Consequently, this same basis of design (Stanton and Pannell's data) should be reliable for new products lines.

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2. W. G. Heltzel, "Fluid Flow and Friction in Pipe Lines," *Oil and Gas Journal 29*, T203-24, June 5, (1930).
3. L. F. Moody, "Friction Factors for Pipe Flow," *Trans. Am. Soc. Mech. Engrs. 66*, 671-84 (1944).

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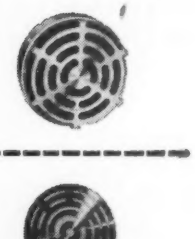

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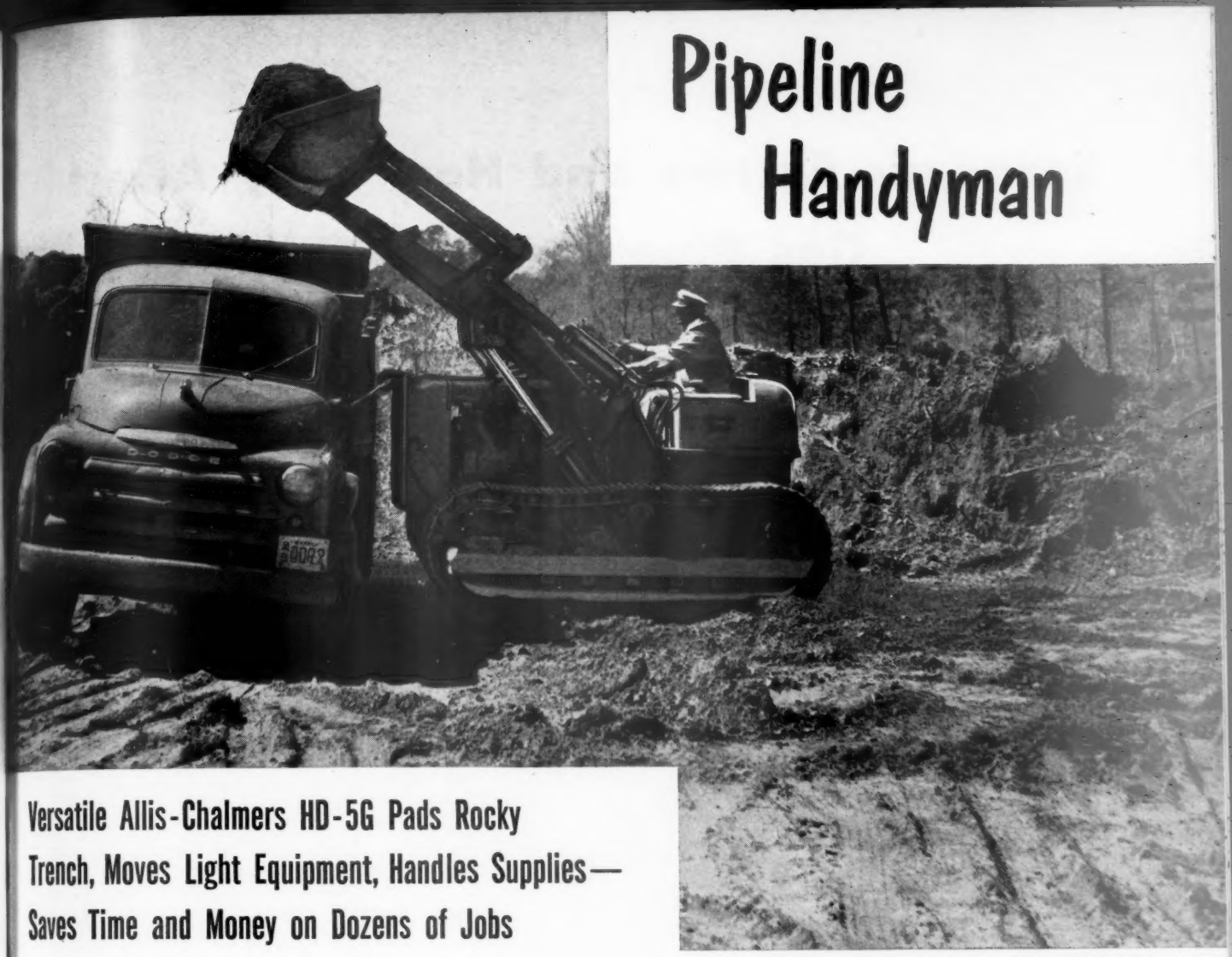

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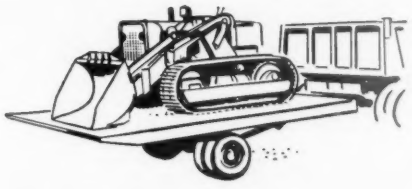

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Economic Factors and How They Affect Gas Pipe Line Design

W. B. POOR*

THE economics of natural gas transmission are each year becoming more competitive, not between pipe line companies particularly, but primarily as the delivered price of gas approaches, or equals the price of competitive fuels —coal and oil. This situation is brought about by the escalation of the field price of gas, where 20 cents per 1000 cu ft is now not unusual, increased steel prices, increased cost of rights-of-way, more stringent control by state authorities, and the approaching adoption of the much needed revision of Section 8 of the ASA Code B31.1 for pressure piping.

In order to maintain a competitive position in the fuels market, the pipe line companies are now faced with the ever increasing responsibility of designing their transmission facilities with due regard to economic factors not heretofore given prime consideration.

Basically, the economic factors affecting engineering design appear to be:

1. **The character of the market to be served and development of load factor.**
2. **The availability and economics of gas storage fields.**
3. **The economic determination of line size versus ultimate installed horsepower.**
4. **Careful predetermination of the pipe line location.**

Markets and Load Factors

The character of the market to be served establishes the load factor at which the pipe line will operate, except as the load factor is increased by means of interruptible industrial sales, peak shaving by customer utility companies with manufactured or LP facilities, or storage facilities located reasonably close to the market area.

The summation of the individual load classes for which there is a market demand establishes the character of the market to be served and falls into eight distinct classifications, with a range in load factor as follows:

Type of load	Percentage
1. Residential general	75—85
2. Commercial general	75—85
3. Residential space heat	23—28
4. Commercial space heat	23—28
5. Small industrial	60—75
6. Large industrial firm	60—75
7. Industrial interruptible	None
8. Company use and unaccounted for	70—75

A typical annual and maximum day load for a service area of 1,000,000 population might then run as follows (Table 1) for the firm load requirements where the area experiences a 7000 deg-day-deficiency (DDD).

Such a load factor imposed upon a long distance transmission line is, generally speaking, economically unfeasible, as the facilities would be operated on an annual basis at only 41.2 per cent of maximum day capacity. The remedy may be found in one of three ways or in a combination of them as follows:

(1) Interruptible industrial sales
(2) Peak shaving
(3) Natural gas storage operations

For example, if as much as 45,000 MMcf of interruptible industrial gas may be sold—and this is almost entirely a price situation—the load factor to the pipe line becomes 86.1 per cent, a fairly desirable situation. If, however, the interruptible sales could be increased to 58,600 MMcf annually, the load factor would approach 100 per cent and the pipe line could be operated at design capacity each day of the year.

Peak shaving through the use of customer companies' existing manfactured gas equipment or liquified petroleum-propane or butane air facilities —although being the least desirable method of increasing the pipe line load factor, does have some merit, especially during the early years of load growth after conversion to natural gas.

Storage Operations

As the cost of owning and operating a natural gas pipe line system is nearly a constant, whether all or only a part of its capacity is utilized, the cost of transporting gas on a unit volume basis is almost inversely proportional to the load factor. It has been shown that large volumes of interruptible industrial sales, up to 60 per cent of the annual sales required for 100 per cent load factor, may be impossible. The gas industry has, therefore, in an effort to obtain high load factor operation without interruptible sales, developed various schemes of storage facilities located at or near the market areas.

A listing of various storage schemes with a generalized unit cost figure for investment per 1000 cubic foot is as follows:

Type of storage	Cost per Mcf of storage volume
Underground in depleted gas formations or water bearing sands	$0.40
Underground in excavated caverns	$0.50
Liquefaction	$20
High pressure bottles	$50
Gas holders and spheres	$175—$250

Only underground storage is sufficiently low in cost to permit economic terminal storage in sufficient quantities to level annual load variations. Only the storage in depleted natural gas reservoirs and, to a limited extent, in water bearing sands, has been used to date to store such large volumes. The cavern storage method through mining operations theoretically offers promise where natural reservoirs are not available.

*Ford, Bacon, and Davis, Inc., New York.

TABLE 1.

Class	No. of customers	Consumption factor	DDD	Annual MMcf	Load factor per cent	Max. day MMcf
Residential General	200,000	25 Mcf	—	5,000	85	16
Commercial General	50,000	75 Mcf	—	3,750	85	12
Residential Space Heat (A)	80,000	25 cf	7,000	14,000	27	142
Commercial Space Heat (A)	10,000	75 cf	7,000	5,250	27	53
Small Industrial	200	—	—	6,000	70	23
Large Industrial	10	—	—	2,000	70	8
Company Use and Loss	—	—	—	5,400	70	21
			Total	41,400		275

Note: (A) Included in General Customers.

The combined load factor is: $\frac{41,400 \times 100}{365 \times 275} = 41.2$ per cent

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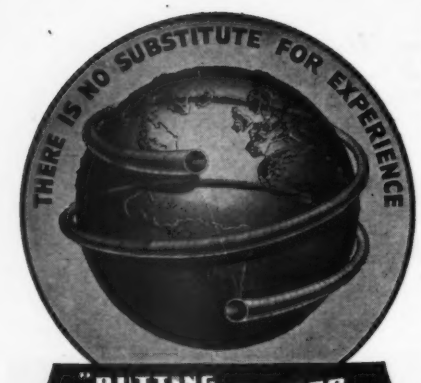

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HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

• Recently saw about the most interesting map of the Gulf Coast that I reckon anybody would care to see. While it didn't highlight the towns and vacation spots — it was lit up like the old-fashioned Christmas tree with red lines and dollar marks. Every red line was an important deal to all of us — because every line on that map represented the pipelines running in every direction from Texas and Louisiana . . . and represented literally barrels of dough! Yes, sir, pipelining is really big business, and it sure gives us a feeling of pride to know that it had been our privilege to have contributed to the building of many of those main lines through our work and equipment. Which reminds me of what 'ole Zeke used to say, ". . . if a man ain't proud of his work — he ain't much fitten for it!"

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There are today in operation, storage fields having a combined capacity in excess of 1200 billion cubic feet and economically serving markets as remote as 300 or more miles. Where such storage fields are available, gas may be delivered in to storage during summer months rather than being sold as cheap interruptible fuel. Such a program enables the pipe line to operate at a high load factor, and preserves deliverability to meet peak winter demands of space heating customers, thereby providing the maximum utilization as a superior fuel.

Pipe Size vs Installed Horsepower

The basic design factors over which the engineer has control are pipe line diameter, maximum operating pressure, pipe wall thickness, compression ratio, and compressor station spacing. For a given diameter and maximum operating pressure, the pipe wall thickness is fixed by the ASA Code for pressure piping and is further modified in some states by more stringent codes. Basically, therefore, the design factors are reduced to four, and the optimum design is obtained by the proper selection of these four principal design factors, to the end that the annual cost of owning and operating the pipe line system is maintained at a minimum.

Two basic procedures may be used for arriving at the best selection of the design factors to produce the minimum annual cost of service. One method is essentially "cut and try" through the use of a large number of calculations involving the use of various values for the several design factors to determine the best combination. The other method involves the use of calculus to determine the proper combination of design factors, the description of which is beyond the scope of these notes.

An example of the comparison of the use of these basic design factors may be of interest. A pipe line approximately 1000 miles in length, requiring a deliverability of 300,000,000 cu ft per day, may be designed as either a 24-in. pipe line operating at 1000 psig, with compressor stations approximately 80 miles apart, or as a 30-in. pipe line operating at 800 psig with compressor stations approximately 240 miles apart, each of which will produce approximately the same cost of service.

There are, however, vast economic differences between these 2 pipe lines. The 24-in. line with station spacing of some 80 miles has been powered to approximately its economic optimum, leaving little or no room for expansion in capacity. Its capital cost is less than that of the 30-in. line, but its cost of operation is somewhat more. The 30-in. pipe line with a station spacing of some 240 miles, however, may be economically developed by additional compressor stations to a capacity of some 550,000,000 cu ft per day.

It may now be concluded that, within reasonable limits, the best use of a given size pipe line is with a compressor station spacing of some 80 miles. For a given initial capacity, with any reasonable probability of increased market growth, a larger diameter line with station spacing of 160 to 240 miles may be developed to greater capacity at a lower cost per 1000 cubic foot of gas transported by the subsequent addition of intermediate compressor stations. The economic problem of evaluating load growth, therefore, becomes of real and vital interest to the engineer in determining the design factors.

Location and Piping Code

It is hoped that the much needed revision of Section 8 of the ASA Code B31.1 for pressure piping will be adopted before the year end. This code will govern the physical design of pipe line systems. The revised code provides for four construction types, each having its specific design factor ranging from 0.72 to 0.40 as applied to the specific minimum yield strength of the pipe. In addition, there are prescribed four "class locations" as related to exposure and population indices. Each of the four class locations is related to its respective construction type.

For example, class 1 location, type A construction for a 30-in. 780 psig working pressure pipe line with 52,000 psig minimum yield steel requires a pipe wall thickness of 0.312-in. or 261.58 tons per mile. Should the class become 2 by reason of physical location, the type becomes B requiring a pipe wall thickness 0.375-in. or 313.24 tons per mile, an increase of 20 per cent in steel required. Such a situation might well be mitigated in the choice of location of the pipe line in the field.

Conclusion

It is the writer's opinion that the proper evaluation of the economic factors affecting the design of a pipe line is basically the responsibility of the engineer. Extreme care and judgment must be exercised when designing pipe line systems in determining the character and magnitude of the market, providing the optimum relationship between pipe size and compressor station spacing, the interpretation of the governing design and construction codes, and the physical location of the pipe line itself in order that the facilities may obtain an economically competitive relationship with other fuels.

Acknowledgment

This discussion was presented before the Committee on Pipelines, Construction Division, American Society of Civil Engineers, New York City, October 21, 1954.

* * *

FIG. 1. First modified scraper used on West Texas sour crude line that included sizes from 6 to 8-in. cement-lined pipe. Other scrapers have been modified for 3 to 4-in. and 8 to 10-in. lines.

FIG. 2. Closeup view of scraper after considerable use shows how lead disc wears more than following disc. Lead disc is removed, moved to lead position, and a new disc placed in the following position to obtain maximum service from the expandible discs.

P 615.63

Expansible discs mounted behind standard discs enable scraper use when different pipe diameters are encountered on same line

EXCLUSIVE

Modified Scraper Cleans Varying-Size Lines

O. C. MUDD*

CONVENTIONAL pipe line scrapers are designed for operation through lines with little if any change of internal pipe diameter. In tapered pipe lines, where pipe diameters are progressively increased or decreased, scraper trap installations are necessary at the terminals of each size line to allow insertion and removal of the scraper.

Alterations of lines, particularly in gathering systems, made in the interest of better economy, often result in variations of pipe size. These varying size lines present problems where scraping is necessary.

Some of these are:

1. Scrapers for each size line.
2. Investment in scraper traps at the terminal of each size line.
3. Oil spills causing property damage at trap locations where proper drainage and disposal cannot be provided.
4. Personnel time required to handle scraper runs.

Scraper modifications have been accomplished that allow continuous runs in varying size lines where the larger internal diameter exceeded the smaller by no more than 33 per cent.

The first modification of a scraper was made during 1949 to allow a continuous run in a West Texas sour crude line including sizes from 6-in. cement lined to 8-in. cement lined. This initial trial scraper is shown in Fig. 1. Scrapers of this design have continued to serve in cleaning this line. Additional scrapers have been modified for lines of 3 to 4-in. and 8 to 10-in.

These modified scrapers are equipped with standard propelling discs for the smaller size pipe to be encountered and the newly developed discs, in pairs, are mounted behind each standard disc.

The mounting of expansible discs in pairs with proper relation to each other is necessary to obtain effective sealing of the expanded disc apertures. These combined discs are held in place by the normal disc retaining parts.

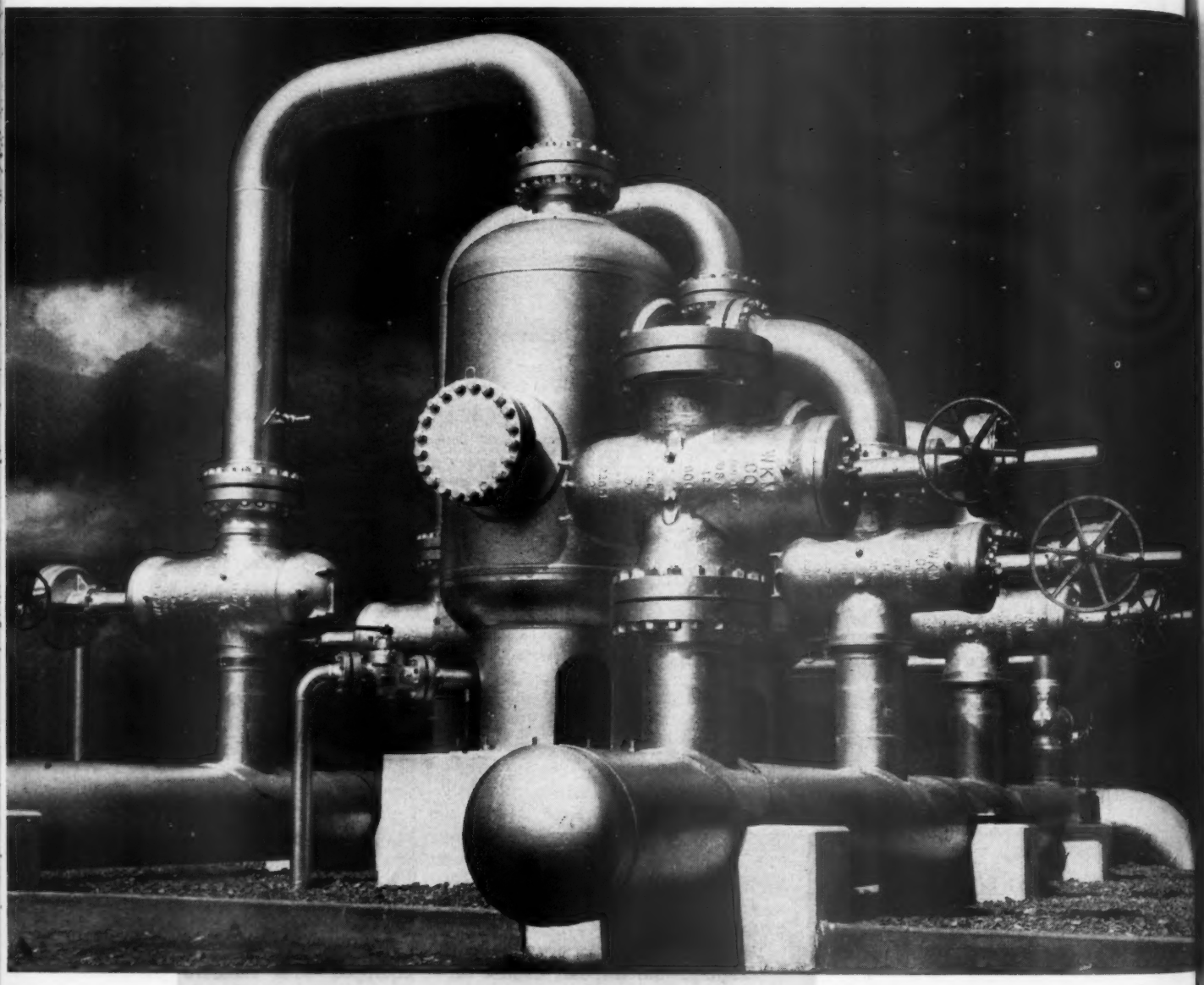
The disc mounting spindles require modification to accommodate this extra disc thickness on some types whereas others can be modified by altering spacer sleeves.

*Senior corrosion engineer, Shell Pipe Line Coporation, Houston, Texas.

XUM

Typical

. . . of pipeline installations all over the world is this view of W-K-M Through-Conduit Valves at a recently completed Gulf Interstate Gas Company Compressor Station. It is but one of five such stations in which W-K-M Valves are employed, in addition to the many larger W-K-M Valves used in the line itself.



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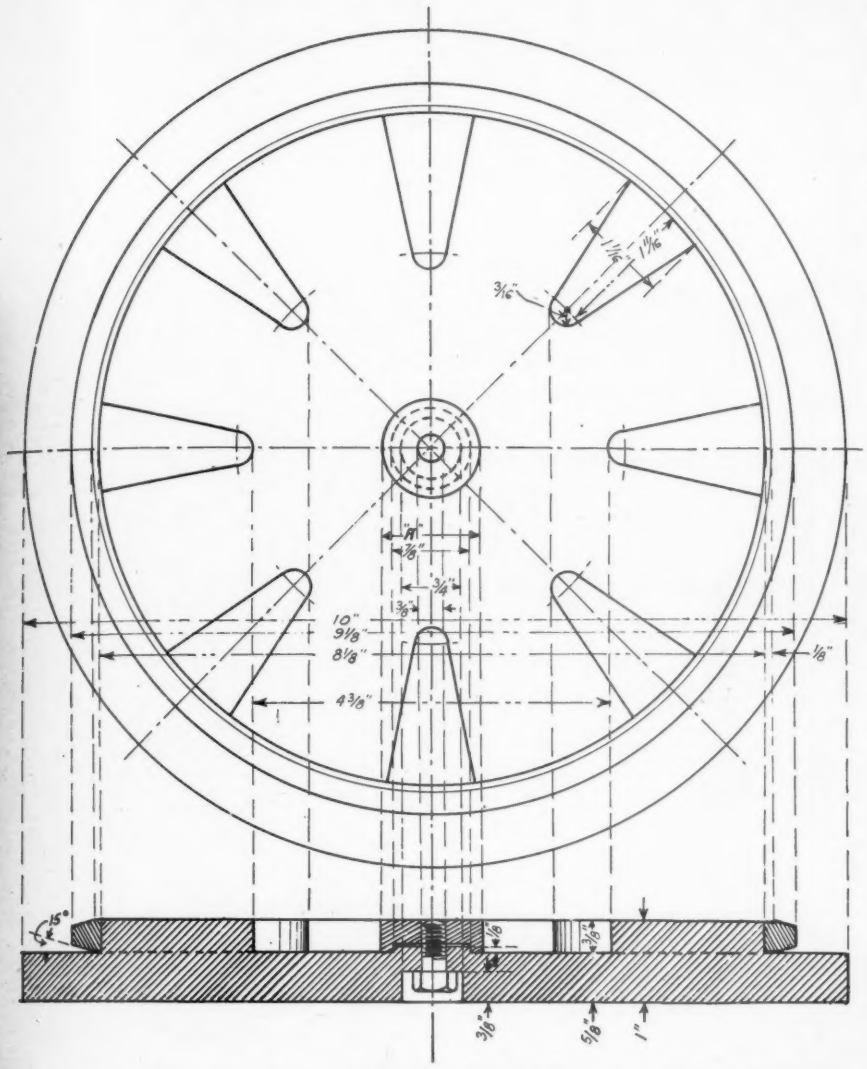

FIG. 3. Mould design for discs operating in 6 to 8-in. lines. Experimental discs were initially cut from neoprene. Trials for disc form and thickness determined best dimensions before dies for moulding were made.

The metal reinforcing discs behind the expansible discs need to be of a diameter slightly less than the dimension between the bottoms of opposite disc apertures.

Basic design of these expansible discs requires periphery division into sufficient equal segments with intervening apertures of a depth to allow easy flexure at the segment root.

The aperture width must be less than the segment width and the sum of the segment periphery widths equal slightly less than the interior circumference of the smaller diameter disc.

Experimental discs were made initially by cutting from neoprene sheets. Trials for disc form and thickness determined preferable dimensions before dies were made to allow moulding. The mould design, made from these dies, for discs operating in 6 to 8-in. pipe, is illustrated in Fig. 3.

Discs of moulded neoprene having a 70 Durometer hardness give better service than those cut from equivalent sheet material.

During operation the lead disc of a pair wears down more rapidly than the following disc. When the lead disc edge has worn thin it is removed and the following disc moved to the lead position with a new disc following thus obtaining a maximum of service from each disc. Fig. 2 shows the effects of wear on these expansible discs.

Scrapers equipped with expansible discs have demonstrated their value through the elimination of many scraper traps, reducing scraper handling time, better scheduling of scraper runs, and reduced oil losses at traps, which occasionally cause property damage. * * *

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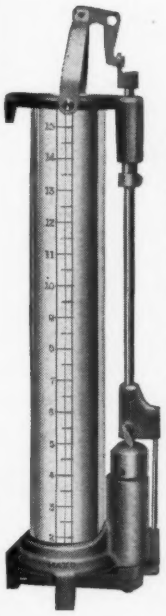

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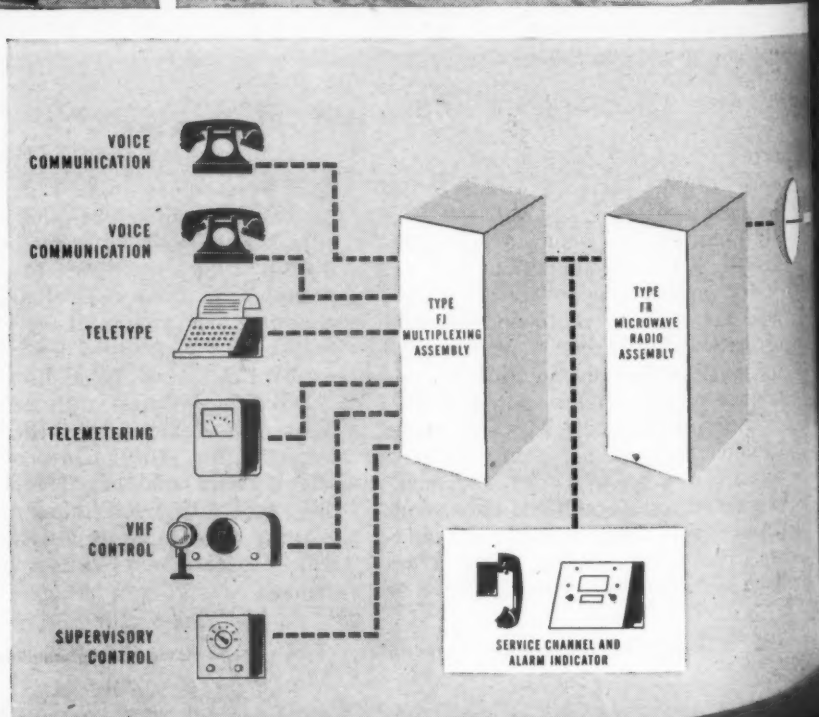

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J-02290

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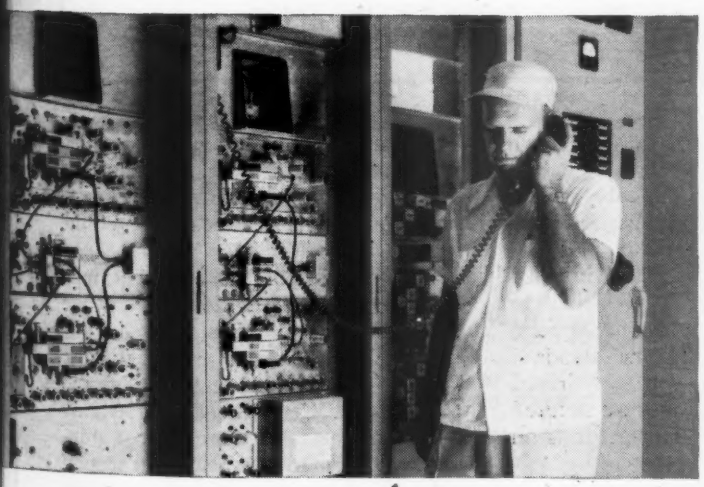

Here is a typical microwave installation at an unattended station. This package includes stand-by radio with automatic switchover—assuring extreme reliability. A total of 30 voice channels is available, each of which can be subdivided for as many as 15 telegraphic functions.

The "eyes and ears" of centralized control are these supervisory relays and telemetering receivers. The Freq-O-Tron* telemetering equipment provides constant intelligence on pressure, flow, tank levels—for use with indicating or recording instruments. The supervisory relays control the Westinghouse-pioneered "automatic check-back" system, a time-proved method for positive remote control.

*TRADE MARK

XUM

Modern Maintenance:

Blanket Method of Flange Insulation Cuts Turbine Downtime for Inspection

ONE of the most annoying headaches faced in internal inspection of a turbine has been the excessive time involved in removing and replacing thermal insulation on the horizontal flanges. In addition to the cost of the man-hours involved, as much as four days of much-needed operating capacity is lost while the turbine is down being insulated. A blanket method of turbine flange insulation has recently been developed which requires only a fraction of the time in removal and replacement consumed in the two most common techniques applied in the past.

The most widely used technique has been to cover the entire turbine shell and flanges with a plastic insulation such as mineral wool cement in thicknesses from 4 to 9 in. In order to remove the upper turbine shell for inspection, the hardened insulating cement must be knocked away from both the nuts and bolts joining the flanges and the flanges themselves. After the turbine has been inspected, repaired and reassembled, several days are required to reapply the insulating cement—at considerable financial loss to the company, particularly in 24-hour central-station operation.

In the second most common method, the flanges are boxed-in by sections of insulation cut to size and wired in position. The cracks in the box structure are then filled with insulating cement and a cement finish is usually applied. The insulation is much easier to remove than in the first method but is equally difficult and time-consuming to replace. In addition, much of the insulating material is lost at each inspection.

The blanket method of turbine flange insulation (shown in the detailed cross-section, Fig. 1) does not disturb the insulation at all but requires only the cuttings and replacement of the wires. As in the other two insulating techniques, the turbine shell itself is covered with insulating cement (several layers of mineral wool cement separated by one-inch wire mesh in Fig. 1).

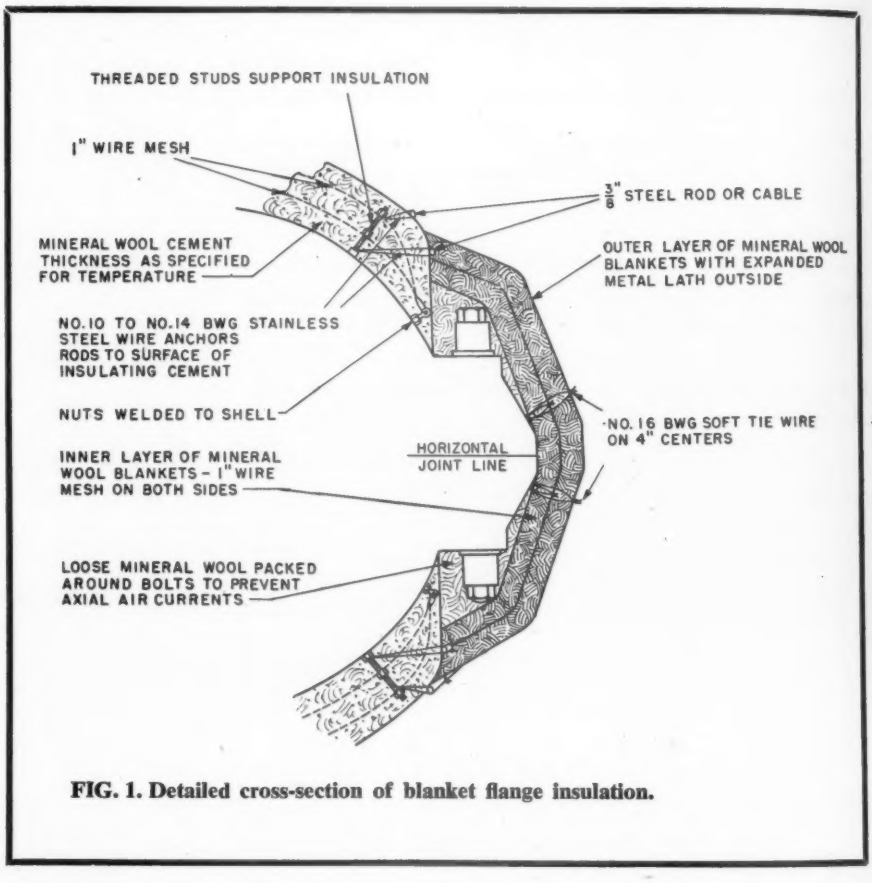
THREADED STUDS SUPPORT INSULATION
1" WIRE MESH
3/8" STEEL ROD OR CABLE
MINERAL WOOL CEMENT THICKNESS AS SPECIFIED FOR TEMPERATURE
OUTER LAYER OF MINERAL WOOL BLANKETS WITH EXPANDED METAL LATH OUTSIDE
NO. 10 TO NO. 14 BWG STAINLESS STEEL WIRE ANCHORS RODS TO SURFACE OF INSULATING CEMENT
NUTS WELDED TO SHELL
NO. 16 BWG SOFT TIE WIRE ON 4" CENTERS
HORIZONTAL JOINT LINE
INNER LAYER OF MINERAL WOOL BLANKETS - 1" WIRE MESH ON BOTH SIDES
LOOSE MINERAL WOOL PACKED AROUND BOLTS TO PREVENT AXIAL AIR CURRENTS

FIG. 1. Detailed cross-section of blanket flange insulation.

The cement covering is beveled down on both sides of the flange.

A ⅜-in. steel rod or cable is extended along each beveled edge parallel to the flange and is held in place by stainless steel wires from the threaded studs welded to the turbine shell to secure the 1-in. wire mesh. Mineral wool blankets, usually the standard 24 by 96-in. size, are cut and shaped to fit over the flange and are secured with soft tie wires to the steel rods on either side.

The flange is insulated with two layers of blanket insulation secured in the same manner to two sets of rods. The inner layer of insulation has one inch wire mesh on both sides, while the outer layer is applied with wire mesh on the inside and a facing of expanded metal lath on the outside. As the turbine shell will be covered with a sheet metal housing no finish is installed over the blanket insulation.

As shown in Fig. 1, the blankets may be further secured by tie wires through the insulation from nuts welded to the flange. These tie wires, as well as those holding the blanket edges together and to the steel rods, are spaced at roughly 4-in. intervals. Frequently, loose mineral wool insulation is packed in around the bolts to prevent axial air currents. Because blanket insulation is more efficient, smaller thicknesses are equally effective in the normal turbine operating range from 900 F to 1100 F. Considering both relative thermal conduc-

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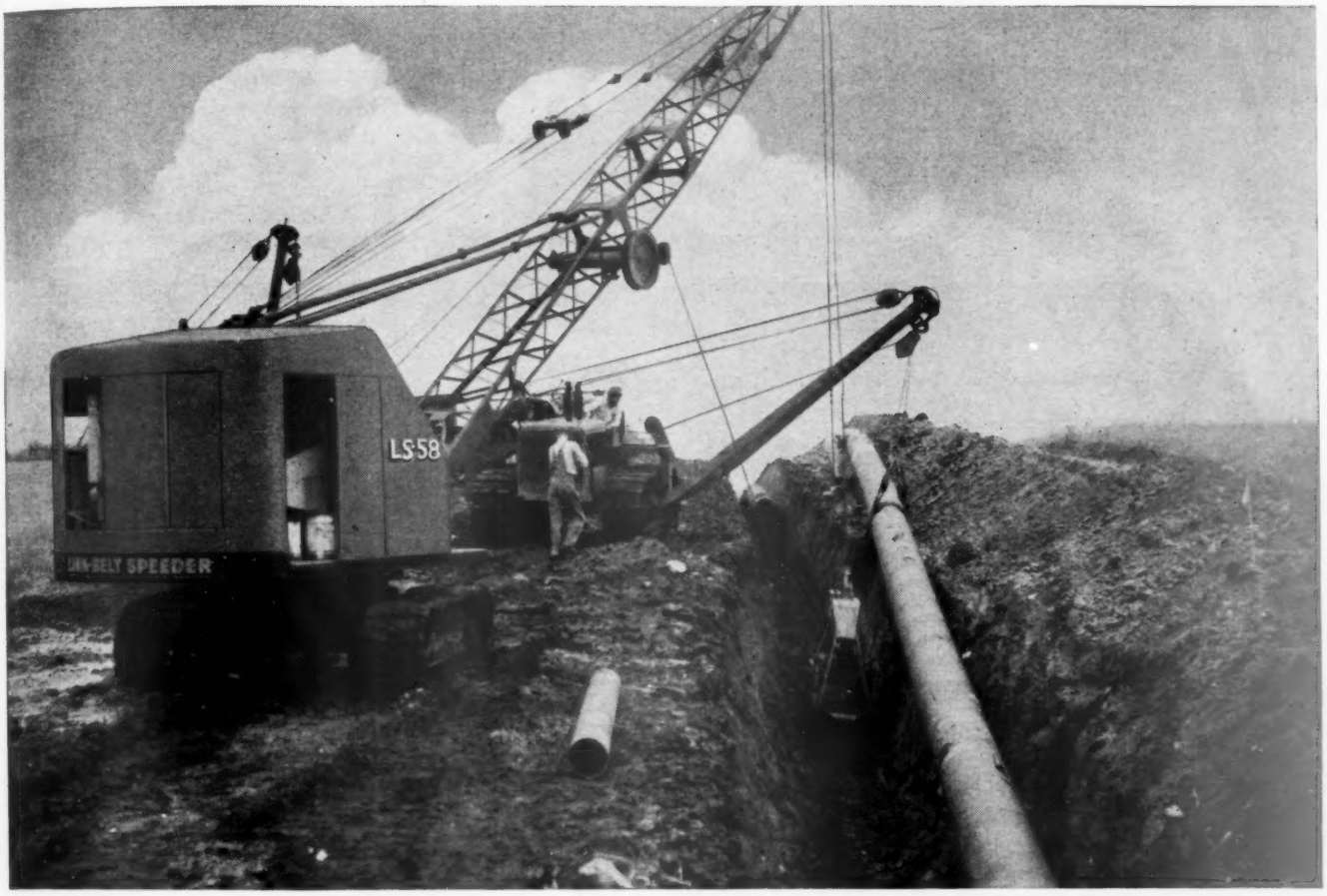

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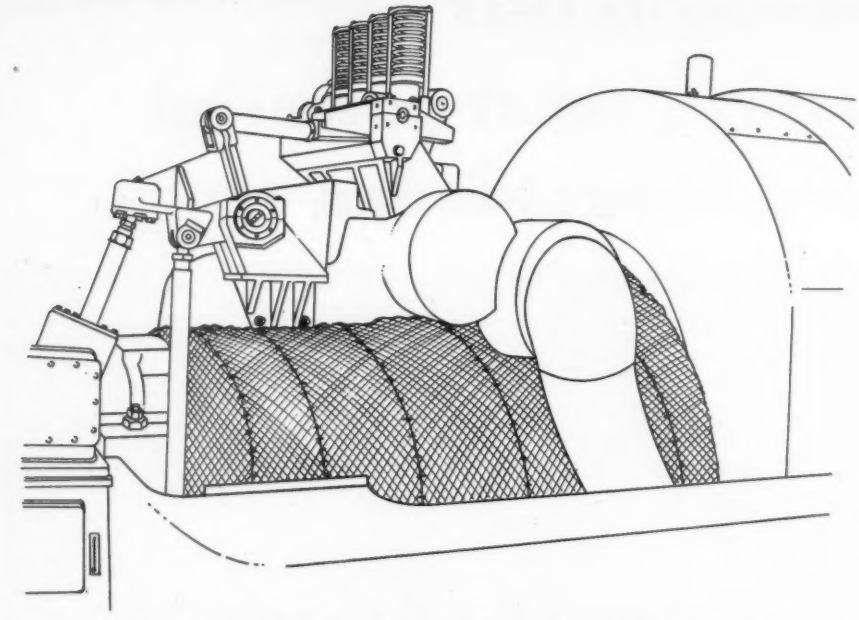

FIG. 2. Turbine shell and flange after being completely insulated.

tivity and average temperature at the flanges, the blanket thickness has been roughly assumed by several engineers as 60 per cent of the specified maximum thickness of insulating cement on the hottest section of the turbine shell. For example, the 9-in. maximum cement thickness commonly specified would indicate a total blanket thickness of 5½-in. on the flanges.

Two layers of blanket insulation are normally used because a single layer as thick as 5½-in. would be too difficult to shape around the comparatively short flange section, as application must often be made in very confined space. The thickness is logically divided somewhat evenly between the 2 layers, for example a 2½-in. and a 3-in. layer for a total of 5½ in. Because it is possible that standard galvanized wire might oxidize at the usual turbine operating temperatures, monel wire mesh and even monel tie wires have been specified to insure trouble-free service.

The drawing in Fig. 2 shows the appearance of the turbine shell and flange after being completely insulated. The blankets are represented by the cross-hatched area (seams laced with wire) while the insulating cement above the blankets and on the large piping is shown white. In this case, the steel rods have been spaced wider apart than in Fig. 1 so that the blanket insulation covers a greater part of the turbine shell on either side of the flange.

The flange insulation is removed simply by cutting the tie wires to the steel rods and those attached through the insulation to the expanded metal lath facing on the outside. The blanket covering is then lifted off and stockpiled near the turbine in several large sections during the inspection period. After inspection is completed, new tie wires are simply attached to the rods and welded nuts and the blanket sections are wired back in place. * * *

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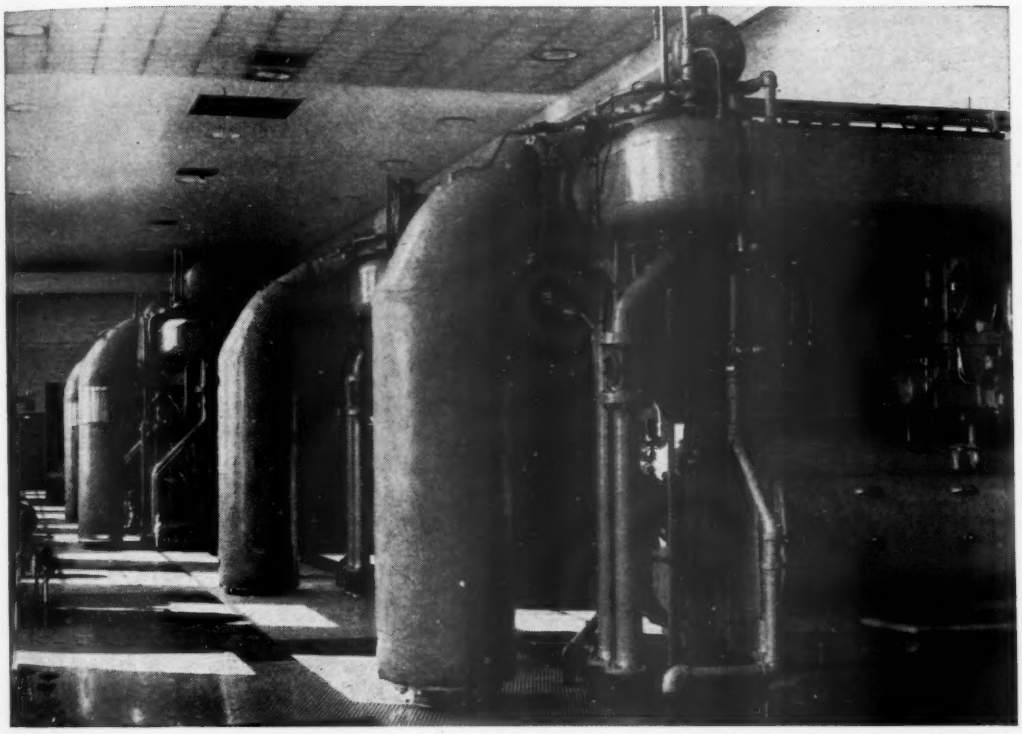

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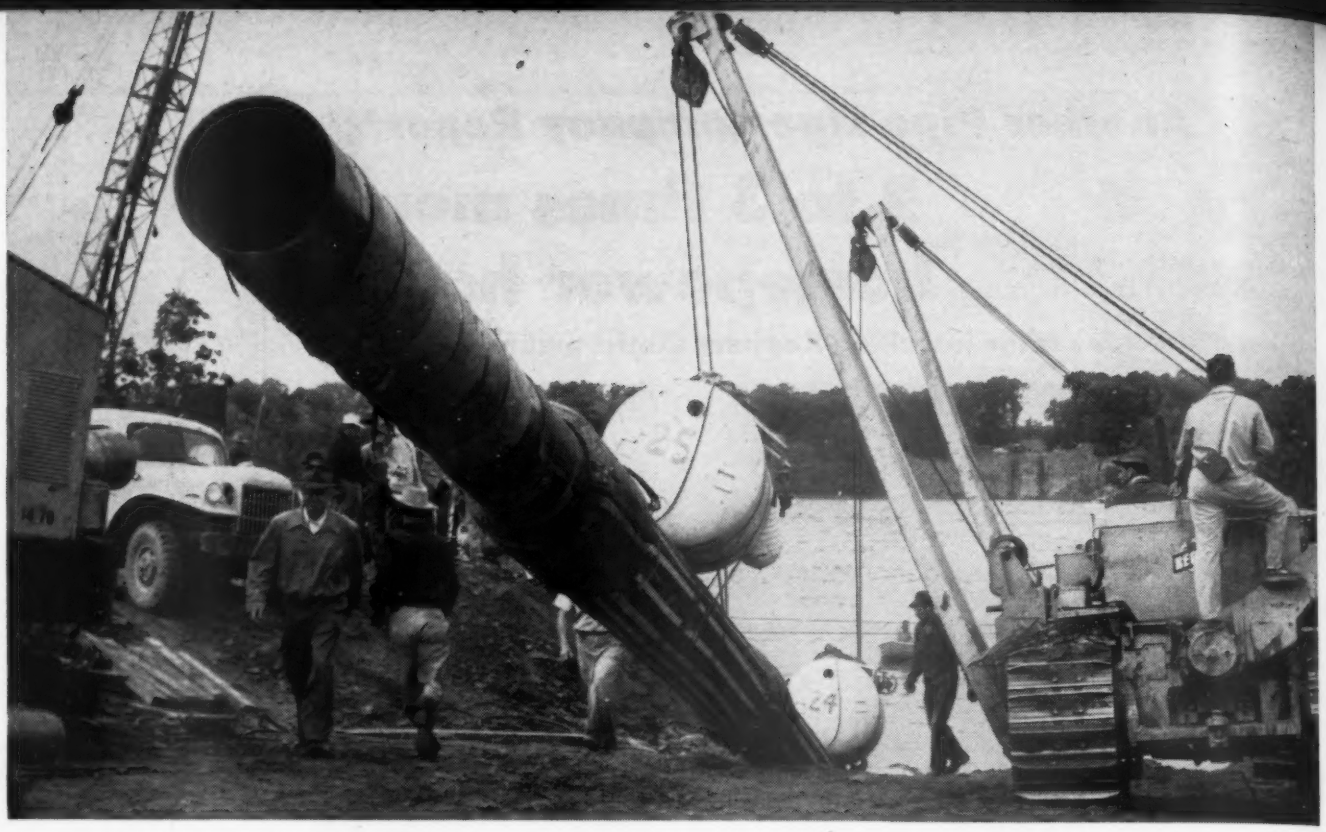

One of six 700-ft strings of 20-in. pipe for dual crossing of Niagara River — Linking Tennessee Gas Transmission's lines with Trans-Canada's 80-mile Niagara-Toronto line — goes into the river.

P 623.371

Niagara Crossing Links Canada With Texas

Natural gas soon to be flowing into Canada from southwestern U. S. with completion of first phase of Trans-Canada system; imports to supply Toronto until all-Canadian line completed in 1956

NATURAL gas from the southwestern United States will soon be flowing into Canada with the completion of a dual 2100-ft, 20-in. river crossing across the Niagara River, linking the facilities of Tennessee Gas Transmission Company with the Niagara-Toronto line of Trans-Canada Pipe Lines, Ltd.

Trans-Canada's 80-mile, 20-in. Niagara-to-Toronto line will connect with the distributing facilities of the Consumer's Gas Company of Toronto. Through the line, which will cost $7,500,000, Toronto will be supplied with natural gas from the United States until November, 1956, when Alberta natural gas is scheduled to be available through the main Trans-Canada line.

The Niagara line, with an initial capacity of more than 115,000,000 cu ft of natural gas per day, is part of the 2200-mile Alberta-to-Montreal natural gas transmission project being undertaken by Trans-Canada Pipe Lines.

The arrangement by which natural gas will be made available in Toronto this year, will enable Consumer's Gas to build up the market in the area in advance of the arrival of Alberta natural gas. When Alberta gas is available, the Niagara line will be used to carry it into southwestern Ontario. It may also carry surplus Alberta natural gas for sale to Tennessee Gas Transmission for distribution in the United States.

The Niagara crossing, located about 3 miles north of the Lewiston Bridge where the bluffs were levelled to a gentle slope, was completed in 9 hours. Major problems for the pipe line were the eight-mile-an-hour current, described as one of the fastest ever encountered on a job like this, and the hard rock bottom of the Niagara River, at a maximum depth of 54 ft, through which a ditch to receive the pipe had to be cut.

EXCLUSIVE

The 48-mile link between the Niagara and the main Tennessee Gas Transmission artery was constructed by Bechtel Corporation, which also constructed the crossing. Sub-contractors for the crossing are Merritt-Chapman and Scott—blasting and dredging the ditch; and Collins Construction Company, for pulling the pipe across the river.

Two 20-in. lines, each 2100 ft long, were laid across the river. Two ditches, each 7 ft deep, were cut in the limestone bed of the Niagara River to receive the pipe. After each crossing was completed the ditches were back-filled by a dredging barge. "Skin" divers, operating from a boat equipped with a fathometer, kept a constant check on the ditches to keep them clear of silt drifting downstream.

Current, silting, the need to do a lot of work "blind," and the enormous

strains imposed on cables during the pulling of the pipe posed special problems for the pipeliners.

For the Niagara crossing, special precautions were taken to prevent damage to the pipe coatings during the crossing work. Asphalt felt was put over the coating as a rock shield, and strings of 2 by 2-in. wooden slats were placed around that as additional protection.

Because there was not enough room on the American side of the river to string out the 2100 ft of pipe required for each crossing, pipe was welded into 6 lengths of 700 ft each—3 for each crossing.

As the divers and the fathometer checks indicated the ditch in the river bed was clear, 8 side boom tractors carried pipe lengths to the river bank where they were directed into the ditch on the U. S. shore. On the Canadian side, a winch pulled pipe across the river. The winch was equipped with a dialometer to indicate the tension on the cable.

Cast iron weights, weighing about 3400 lb each, were spaced at 24-ft intervals.

After the pull was completed, divers walked the pipe to make sure it was in the ditch as planned. The fathometer provided another check on the position of the pipe after pulling. * * *

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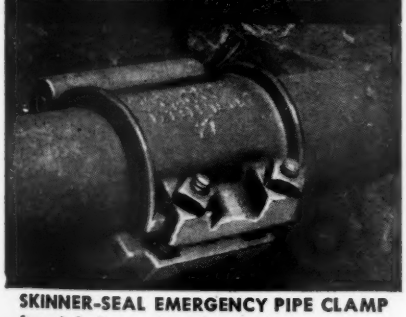

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Canal crossing sections being made up for Trans Canada line.

Gulf Interstate Acquires 5-Story Office Building

Gulf Interstate Gas Company has acquired ownership of a new 5-story office building in Houston, Texas. The new structure, to be known as the Gulf Interstate Building, contains 50,000 sq ft of office space.

Gulf Interstate Gas Company will occupy the major portion of the upper 3 levels in the building, which will serve as headquarters for its new 1150-mile, $130,000,000 pipe line system, scheduled to go into operation on November 1, transporting 375,000,000 cu ft of gas daily from south Louisiana to West Virginia for the Columbia Gas System.

Other occupants of the building include Gulf Interstate Engineering Company, a recently-formed subsidiary of Gulf Interstate Gas which has entered the pipe line engineering field; Columbia Gas Service Corporation; Westinghouse Electric Corporation, and the New York Life Insurance Company.

Trunkline To Install New Texas Station

Trunkline Gas Company has received FPC approval to construct a 6350-hp compressor station on its transmission system in Texas.

The new compressor station will be located at Edna, Texas, on Trunkline's supply line. Total estimated cost of construction is $1,563,800. Station will contain one compressor unit, and is designed to help assure peak deliveries at all times as required on Trunkline's system. It also will protect reserves committed to the project, and spread —rather than concentrate—the highest takes of gas, the company said.

Welland Canal Crossing Completed by Niagara

One of the busiest commercial waterways in the world was crossed recently by the natural gas line of Niagara Gas Transmission Company, subsidiary of Trans-Canada Pipe Lines, Ltd. (See page D-60, this issue)

The 80-mile, 20-in. line was laid in record time by Canadian Bechtel, Ltd., through generally good pipelining country. Terrain is fairly level, principal hazards being the many orchards that involve heavy compensation payments and 500 properties crossed.

The commercial waterway crossing, of the Welland Canal, was handled by a very small crew under a subcontract to McQueen Marine, Ltd., of Amherstberg, Ontario, from Conyes and Shaw Construction Company, Ltd.

A large derrick scow with a 90-ft boom clammed out rock from the ditch as platform-mounted drills driven by air compressors cut the shot holes for the charges of dynamite. A barge lighter with a 65-ft boom, capable of handling 800 tons in a scoop, transferred the rock from the scow. The 230-ft crossing was buried in an 8-ft ditch under the 25 ft of water in the canal.

Welland Canal, which joins Lakes Erie and Ontario parallel to the Niagara River, carries upwards of 40 vessels a day, bypassing the famous Niagara Falls. Ditching had to be scheduled on close timing to avoid shutting off more than half the canal at once, as well as to avoid conflict between the contractor's equipment and the grain boats, oil tankers, ore carriers, and general freighters.

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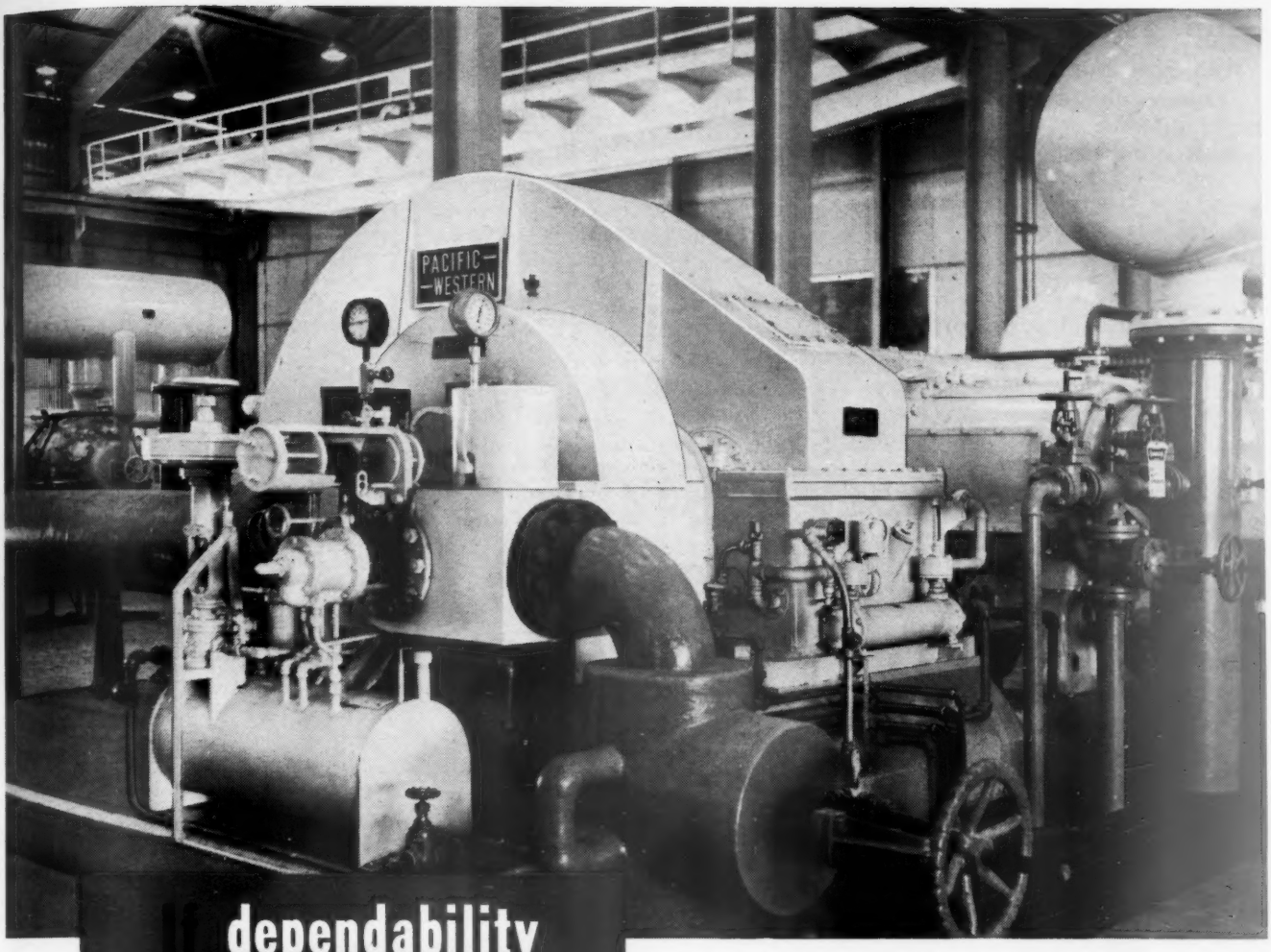
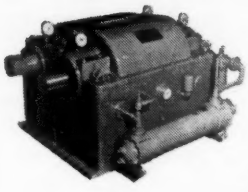
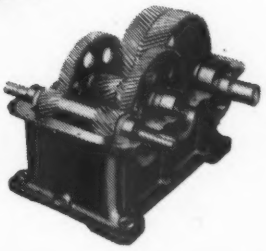


One of two Western Gear Works speed reducing units in the new ammonia plant of Brea Chemicals, Inc., Brea, Calif., a subsidiary of the Union Oil Company of California. The units are driven by Elliott Steam Turbines at 3600 RPM input, delivering 1250 HP at 300 RPM output to drive Cooper-Bessemer reciprocating hydrogen compressors.

If dependability is a must... be sure it's a WESTERN GEAR drive



Custom-modified high speed unit



Parallel shaft speed reducer

When progressive companies design and construct pumping stations, they almost invariably specify Western Gear speed reducers or high speed units for pumping applications. Because they know that Western Gear, with 66 years of experience in the manufacture of power transmission equipment, can be relied upon to build units that perform with unfailing dependability and utmost efficiency.

In the highly specialized pumping field, Western Gear Works supplies the right answer when it comes to speed reducers, high speed units or other mechanical power transmission equipment.

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Latest In Welding At AWS Fall Meeting

Advances in welding will be featured at the annual fall meeting of the American Welding Society in Chicago, November 1-5. Papers to be presented cover new "contact" type electrodes, hard surfacing methods, pressure vessel and piping welds, design, and production.

Trans Prairie Line Important Canadian Crude Outlet

A small but important crude oil pipe line being laid in southwestern Manitoba will insure weather-proof transportation for oil from the Virden-Roselea and North Virden-Roselea fields that now contain nearly 100 wells between them. The 13-mile, 6-in. line will join these fields with the east end of the Daly field, which has a pipe line connection with the Interprovincial pipe line at Cromer station. The newly incorporated Trans-Prairie Pipelines, Ltd., which has acquired the existing 9-mile, 6-in. line, will operate the entire system and the main gathering lines that feed into it. The Daly field has 118 wells on production and total transportation from the triple-field area is estimated to be capable of reaching 20,000 bbl daily by 1956.

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- Adds important weight to lines where negative buoyancy is a problem . . .
- Can be hauled and strung, roll welded, bent cold, lowered into trench and backfilled by ordinary methods without damage to the coating.

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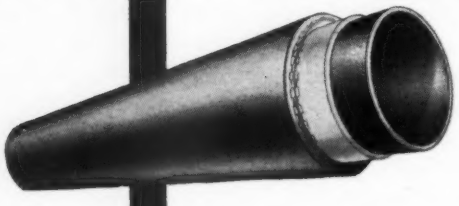

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P. O. Box 263, Harvey, La.

Pipe On Hand, Equipment Ordered For Pembina Project

Pipe for the line that will connect Canada's largest single crude oil reserve with main marketing channels has been stockpiled and stringing is underway. The 70-mile, 16-in. line of Pembina Pipe Line Company, Ltd., is using 58 miles of .312-in. wall and 12 miles of .375-in. heavy wall pipe, the latter for the initial section downstream from the main station. All pipe is 5L by 46 high test welded.

The field gathering system will be one of the largest in Canada, covering 350 to 375 square miles and serving a probable total of 3000 to 3200 wells with 325 miles of pipe line. More than half, 178 miles, is scheduled for laying in the 1954-55 seasons. Petrol-Structors, Ltd., is engineer-consultant for the entire project, including the main line construction.

Pipe for the gathering system is 5L Grade A API specification and comprises the following quantities for the current program: 5.7 miles of 16-in., .25-in. wall; 11.4 miles of 12¾-in., .25-in. wall; 18 miles of 10¾-in., .25-in. wall; 9 miles of 8⅝-in., .25-in. wall; 25 miles of 6⅝-in., .188-in. wall; 22 miles of 4½-in., .188-in. wall, and 87 miles of 3½-in., .188-in. wall. Each section of this system, as well as the main line, will be equipped with scraper traps for wax removal. They will be placed in accessible locations, in groups, with all traps, valves, and cross piping above ground.

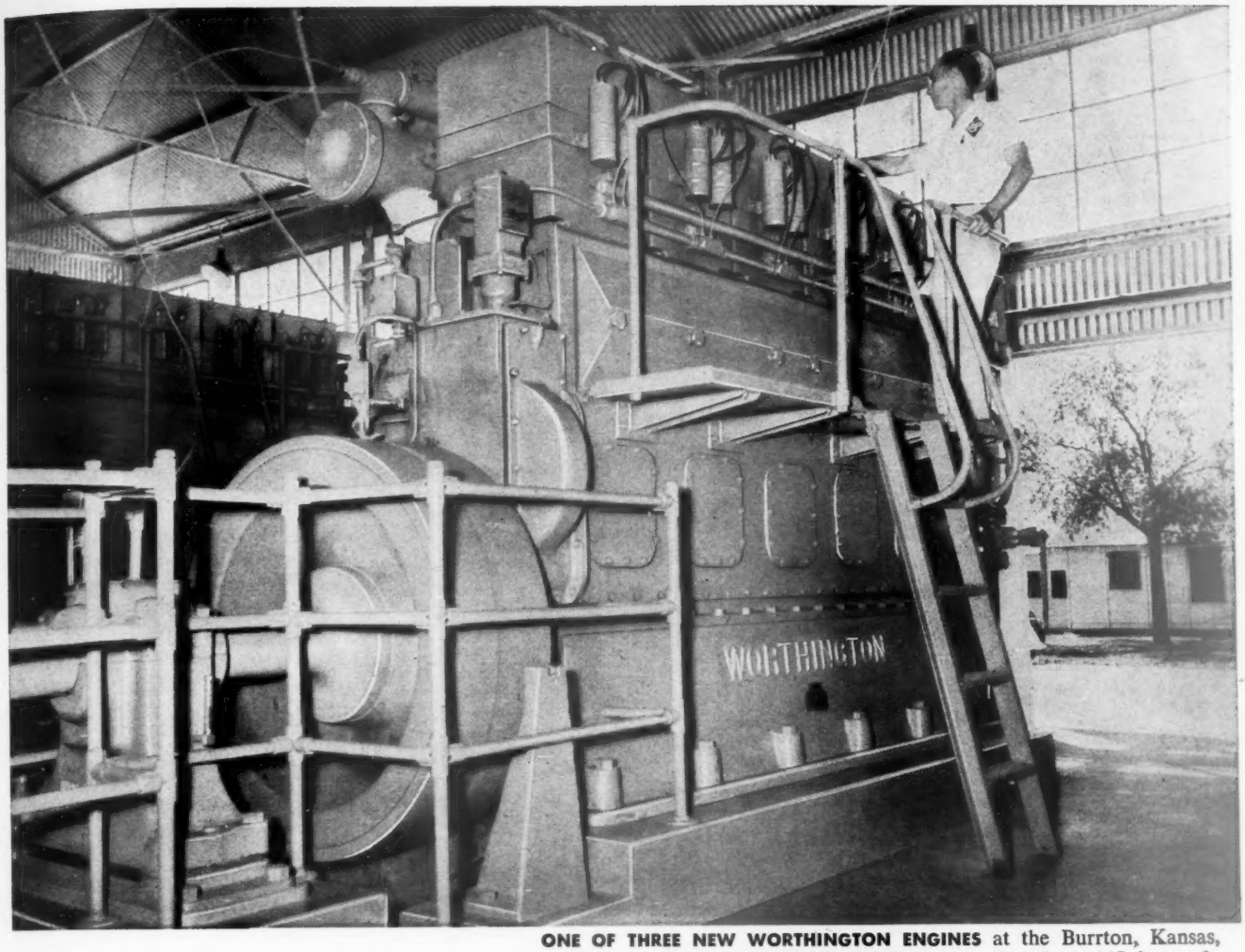
The main line and the gathering system will both be designed to operate at 1200 psi maximum, and pipe will be tested to 1400 psi.

Main line pumping units will be centrifugals, 10 by 12 by 15 models, driven through speed increasers by either 1400 hp 6-cylinder gas diesel engines or electric power units. The original two units will develop total head of 800 psi at indicated throughput of 75,000 bbl per day.

A third unit will increase station discharge pressure to 1200 psi and provide for throughput of 115,000 bbl a day. Ultimate capacity of 150,000 bbl, not likely to be reached for several years, will be attained by merely resetting the governors to increase the engine horsepower.

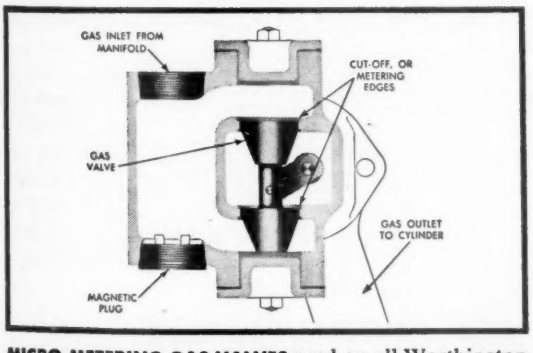
Production batteries, expected to number about 275 when the tributary area is completely developed, will be equipped with 4 by 6 double acting duplex power pumps driven by internal combustion engines, providing pumping rates of between 50 and 150 bbl per hour. They will be electrified when power becomes available to the field.

Estimated cost of the entire system is $15,000,000, with about half to be spent this year.



ONE OF THREE NEW WORTHINGTON ENGINES at the Burrton, Kansas, pumping station of the Skelly Oil Company. Rated at 445 hp each, these engines drive centrifugal pumps through step-up gears.

Skelly Oil buys three more Worthington engines



MICRO-METERING GAS VALVES used on all Worthington spark-ignition and dual-fuel engines assure equal cylinder loading, smooth running at all loads, better speed regulation, and lower maintenance.

You find out a lot about the performance of engines when you live with them 16 years.

Skelly Oil Company had that long to assess two Worthington gas engines installed in 1936 in their old pumping station at Burrton, Kansas. Driving centrifugal pumps through step-up gears, the Worthingtons did a fine job in moving crude oil 52 miles to the Skelly refinery in El Dorado. So when the time came to rebuild the Burrton Station with enlarged capacity, Worthington engines again received the nod from Skelly engineers.

Repeat business like this isn't exactly a surprise to Worthington. But it's still good to know that our old customers — people who have given our engines a real workout for years — keep coming back to us for additional equipment. Let us help with *your* power problems — write Worthington Corporation, Engine Division, Section E.4.6, Buffalo, New York. E.4.6

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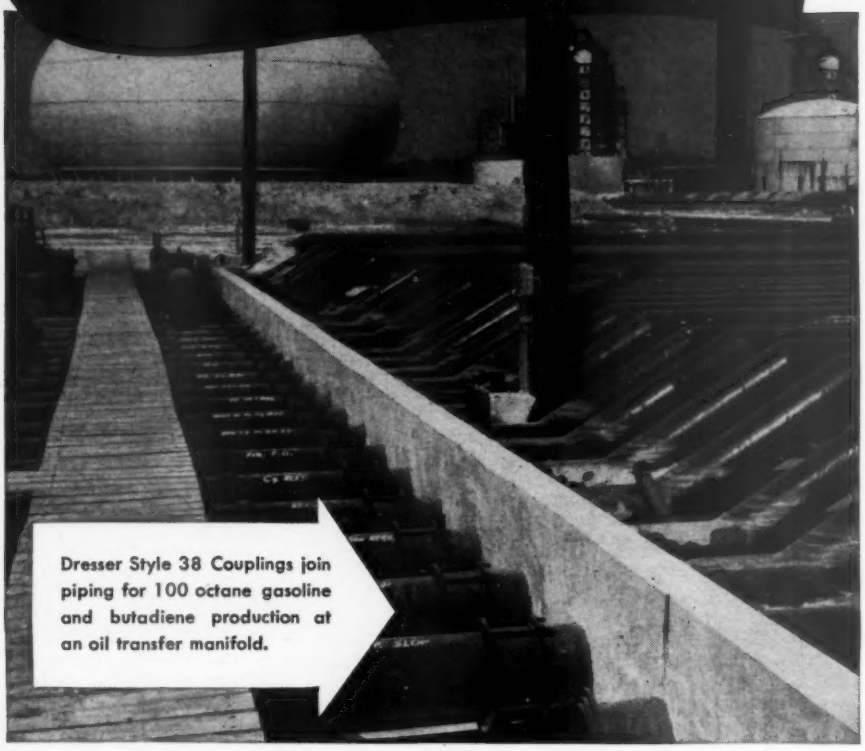

Dresser Style 38 Couplings join piping for 100 octane gasoline and butadiene production at an oil transfer manifold.

You'll find many piping applications in and around oil terminals and refineries where Dresser Couplings will simplify and speed up joining work. They're particularly advantageous for tank and equipment installations.

Dresser Couplings provide attractive features for refinery applications . . . they're easy and fast to install, bottle-tight and safe. The specially compounded rubber gasket permits up to 4° deflection at joints—yet with Dresser Couplings, these joints stay permanently tight.

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Projects

Ohio Loops for TGT Contracted by Price

H. C. Price Company has been awarded a contract by Tennessee Gas Transmission Company to construct 68 miles of 26-in. gas line, divided in four loops extending along TGT's existing 26-in. main transmission line in Ohio. This work is in addition to the construction of 3 loops recently completed in Ohio by Price.

W. H. Stueve

AIEE Honors Stueve With Fellowship

Winfred H. (Bill) Stueve, Oklahoma City consulting electrical and mechanical engineer, was signalled honored by the American Institute of Electrical Engineers during the recent Petroleum Industry Electrical Conference held under AIEE auspices at Tulsa, Oklahoma.

He was elected as a fellow member of the society. The citation stated the award was made for "work for many years in convincing the oil industry that use of purchased electrical power was in many cases more economical than other methods."

Stueve, who was elected a fellow member of the American Society of Mechanical Engineers in 1947, has the distinction of being the only person on the Southwest who is a fellow of both organizations. He was chief electrical engineer during construction of the "Big Inch" pipe line from Beaumont to New Jersey during World War II. He has been called the "father of the use of electric power in the petroleum industry."

Ohio Fuel To Build Station, 46-Mile Line

FPC has granted a certificate to Ohio Fuel Gas Company for construction of 46 miles of pipe line and 3000-hp additional compressor power on its natural gas transmission system in Ohio.

The new facilities are designed to enable Ohio Fuel to receive additional natural gas from its affiliate, United Fuel Gas Company. Both companies are Columbia Gas System subsidiaries.

XUM

Service Pipe Line Magazine Receives Top SAIE Award

The Connecting Rod, Service Pipe Line Company employee magazine, received the top award for the best black and white photograph in the annual Society of Associated Industrial Editors contest. Carl Huss, editor, accepted the award at the society's annual vention in Salt Lake City.

Cities Service Plans Storage Area Facilities

Cities Service Gas Company has requested FPC authority for construction of new natural gas facilities in Anderson County, Kansas, to increase the deliverabilities from three storage areas.

The company proposes to install three 1350-hp units at its Welda compressor station; to build a total of 6 miles of 4, 6, and 16-in. pipe in the Colony, South Welda, and North Welda storage fields, and to drill approximately 55 injection and withdrawal wells in these same 3 fields.

Total estimated cost of the project is $1,426,690. Cities Service declared that the project is designed to avert curtailment of deliveries in the Kansas City area on the peak day in the coming winter and would provide permanent increases in deliverabilities from the storage areas for future use.

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"John Crane" has met this need with the Type 8B hydraulically balanced seals for pressures to 1200 psi.

These seals can be quickly installed and adjusted simply by sliding the entire unit along the shaft into final position. Removal of the top casing is not necessary. This feature alone results in the saving of many man-hours of maintenance work.

Field reports and performance records point to the steadily increasing use of "John Crane" high pressure seals to eliminate problems connected with the handling of hydrocarbons, crudes, gasoline and other petroleum products.

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Accident Prevention Course Available Through AGA

A new accident prevention course for gas industry personnel is now available through the American Gas Association. It is designed to give foremen, supervisors, and superintendents a through knowledge of modern accident prevention techniques. Presented in a two-day seminar form, it restricts straight lecturing to a minimum and leans heavily on visual aids to emphasize the main themes. A pilot run of the course was held recently by Northern Natural Gas Company at Fort Dodge, Iowa, for more than a hundred of its employees.

Texas Eastern Receives Approval on 58-Mile Line

Texas Eastern Transmission Corporation has received FPC approval to construct and operate 58 miles of 20 and 16-in. pipe line from Joaquin to Longview, Texas, at an estimated cost of $3,269,000.

The new pipe line will consist of 26.5 miles of 16-in. line extending from the company's compressor station near Joaquin, Texas, to the Carthage field in Panola County, Texas, and 31.5 miles of 20-in. line from the point of termination of the 16-in. line to the terminus of the company's 24-in line near Longview, Texas.

The new pipe line will permit gas from the company's lines originating at Provident City, Texas, to be transferred to its 24-in. pipe line originating at Longview whereas at present the company has no facilities south of Little Rock, Arkansas, for transfer between those lines. Present plans call for completion of the new pipe line by late 1954.

Badger Line System Construction Progressing

Work on a 122-mile section of the Badger products pipe line between Des Plaines, Illinois, to Madison, Wisconsin is expected to begin shortly. Bids have been received but no announcement made on the awards. Cities Service Pipe Line is building the line for a four-company group.

Work on the East Chicago-Harlem Avenue leg of the line is progressing and tankage and terminal construction at the Madison terminus is expected to be complete this year.

Stockholders Approve Merger of TGT, Production Affiliate

Stockholders of the Tennessee Gas Transmission Company and its affiliate, the Tennessee Production Company, have voted approval of a proposal to merge the production company with and into the transmission company.

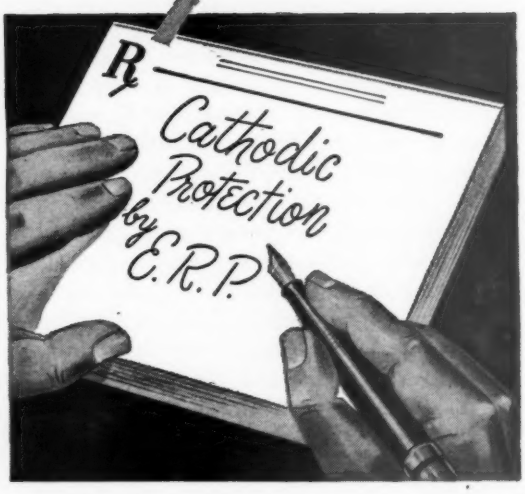
A joint application by both firms will be filed with the Federal Power Commission for approval of the merger. Various legal procedures required are expected to be completed in time for action to become effective by December 31.

Hearings on 497 Miles Of Gas Line Postponed

Hearings on five applications by Northern Natural Gas Company, previously scheduled for October 12, have been postponed by the FPC until November 15 upon request by counsel for the company.

The consolidated hearings involve applications by Northern (1) to construct a 167-mile extension of its pipe line in Minnesota to supply gas service to the Duluth, Minnesota, and Superior, Wisconsin, area; (2) to build a total of about 330 miles of line to supply gas service to 20 South Dakota communities, and (3) to construct facilities to sell 12,000,000 cu ft of gas per day on a firm basis to Allied Chemical and Dye Corporation for use in its La Platte, Nebraska, fertilizer plant. In addition, they involve reopened proceedings on two other applications by Northern, on which hearings were concluded September 21.

℞ FOR CORROSION...



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E-27

pipe line personals

Lauren L. Faucett has been promoted from general accountant to chief accountant of Platte Pipe Line Company. Prior to joining Platte in 1951, he worked as a pipe line auditor. He is a graduate of the University of Kansas.

Shuman Childress, formerly district clerk at Alice, Texas, has been promoted to division clerk of Magnolia Pipe Line Company's western division with headquarters at Midland, Texas. **M. L. Butler,** formerly division clerk at Midland, has been transferred to Oklahoma City, Oklahoma, as division clerk of the northern division. **L. C. Knight,** formerly division clerk at Oklahoma City, has been transferred to Little Rock, Arkansas, as clerk. **Charles Bradley,** who has been district clerk at Little Rock, has been transferred to Alice as district clerk.

A. C. Wilkinson has been named senior vice president of Continental Pipe Line Company, a newly created position. Other recent changes include **John L. Kelly,** Wichita Falls district superintendent, advanced to a new position of vice president in charge of operations; **John D. Morrow,** administrative assistant to coordinator and assistant to the president; **F. C. Whitehead,** chief engineer to manager of development and technical advisor, a new post; **W. K. Burns,** senior engineer to chief engineer; **Earl B. Webster,** assistant to general manager to supervisor of oil movements; **C. Jay Platt,** chief clerk, to new position of industrial relations supervisor, and **R. L. Sanders,** office manager for Yellowstone Pipe Line, becomes chief clerk succeeding Platt.

Henry Hofmann has been named assistant to the president of Tuscarora Pipe Line Company, Ltd. He was formerly manager and secretary-treasurer. **E. L. Ochs** will succeed Hoffman as manager and secretary-treasurer. **G. Warren Miller,** presently assistant treasurer, has been appointed to the combined position of assistant secretary and treasurer. Hofmann has 35 years of service with Tuscarora, Ochs has 25, and Miller 20 years.

W. F. (Bill) Delaney, group leader in Service Pipe Line Company's accounting department, has retired after 32 years of service.

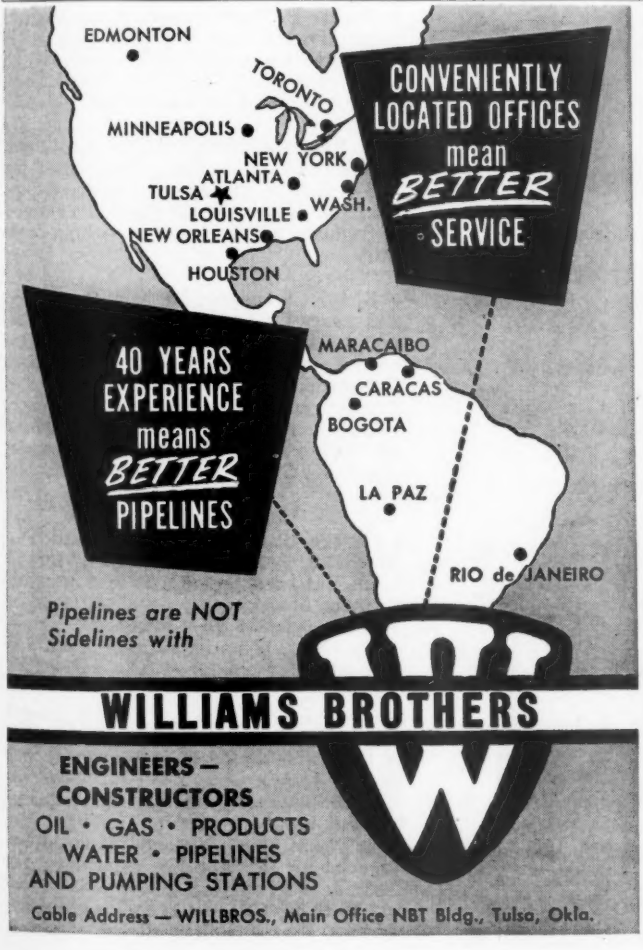
Kim G. Houghlan has been named director of public relations in the newly created public relations department of Platte Pipe Line Company. Prior to his promotion, he was assistant to the president.

George A. Wilson, president of Interstate Oil Pipe Line Company, Shreveport, has been elected president of Yellowstone Pipe Line Company. Other officers elected include **W. L. Kygar,** Continental Pipe Line Company, vice president and general manager; **John D. Morrow,** Continental, secretary; **R. L. Bosworth,** Continental, treasurer, and **P. H. Hunter,** Interstate Oil Pipe Line Company, assistant secretary-treasurer. Directors include Wilson, Kygar, **Joseph L. Seger** of Carter Oil Company, **Thomas Brownfield** of Carter, **W. Turner Clack** of H. Earl Clack Company, **E. L. Hiatt** of Union Oil Company of California, **J. W. Liddell** of Continental, and **T. A. van Griethuysen,** Continental.

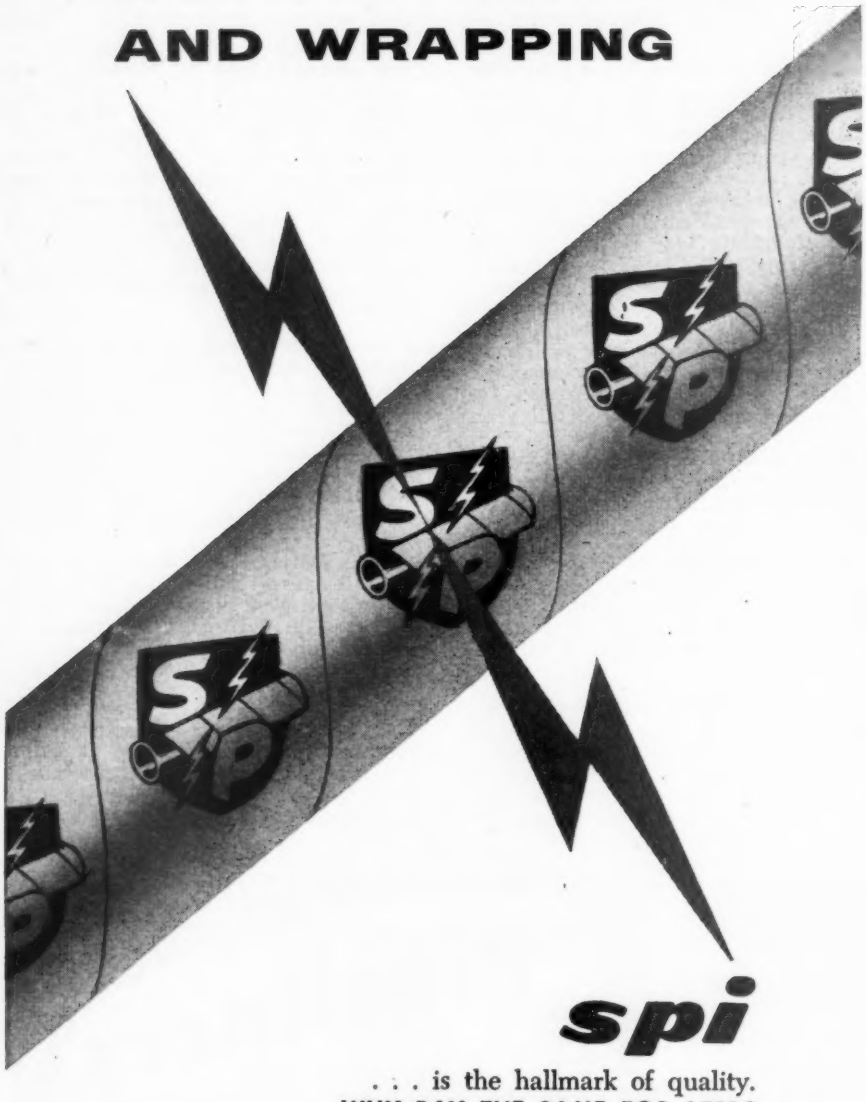
D. D. Dillingham, formerly superintendent of the western pipe line division, has been named superintendent of operations of United Gas Pipe Line Company to replace **D. R. Pflug** who resigned. **Paul Williams** has been appointed chief engineer of United Gas Pipe Line Company and Union Producing Company. Williams replaces **V. E. Hamilton, Jr.,** who resigned.

J. D. Davis, district manager at Jackson, Mississippi, will replace Dillingham as superintendent of the company's western pipe line division. **R. M. Hearin,** assistant district manager at Jackson, has been appointed district manager to succeed Davis.

P. McDonald Biddison, gas consultant and former vice president of Trunkline Gas Supply Company, has been named president and chief executive officer of the Texas-Ohio Gas Company.



THE HALLMARK OF QUALITY COATING AND WRAPPING



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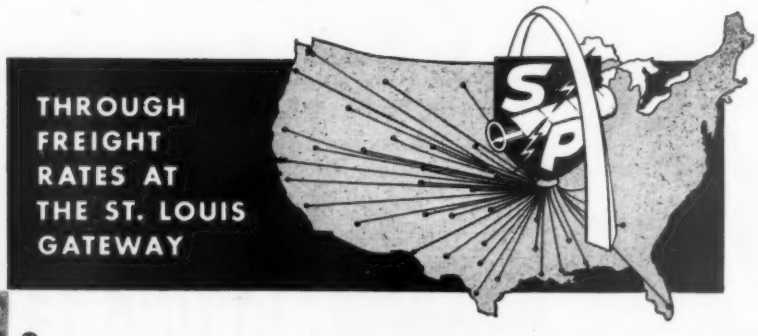

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Personals

▸ **W. L. Kygar,** president of Continental Pipe Company, Ponca City, Oklahoma, has been elected president of the recently organized Cherokee Pipe Line Company. Other Cherokee officers are **John L. Kelly,** Continental Pipe Line, vice president and general manager, products pipe line division; **Ben D. Lutey,** Cities Service Pipe Line Company, vice president and general manager, crude oil pipe line division; **G. R. Preston,** Cities Service, vice president and treasurer; **John D. Morrow,** Continental Pipe Line, and **C. B. Wedum,** Cities Service, assistant secretaries; **R. E. Onstot,** Continental, assistant treasurer. Kygar, Lutey, and Preston were elected to Cherokee's board. Other directors are **T. A. Van Griethuysen,** Continental Oil Company; **K. W. Brill,** Continental Oil, and **Harry Nelson,** Cities Service.

▸ **Roy E. Jones** has been elected vice president of North Shore Gas Company, Waukegan, Illinois. Jones was with North Shore for nine years prior to moving to Miami, Florida, where he has been executive vice president of Peoples Water and Gas Company and Peoples Gas Company.

▸ **P. H. DuVal** has been elected vice president of Arkansas Fuel Oil Corporation. He has been vice president and general manager of the Arkansas Pipe Line Corporation since 1943 and is also manager of crude oil and gas purchases and sales of Arkansas Fuel Oil Corporation. He will continue in those capacities.

▸ **G. L. Maciula** has been transferred to Galesburg, Illinois, as assistant division manager for Service Pipe Line Company's Illinois division. He has been assistant division manager in southern Oklahoma for Service since 1952.

▸ **Parker F. Davis,** assistant communications division superintendent with Texas Pipe Line Company, has retired after 38 years of service. He joined Texas Company in 1916 at Dallas, Texas.

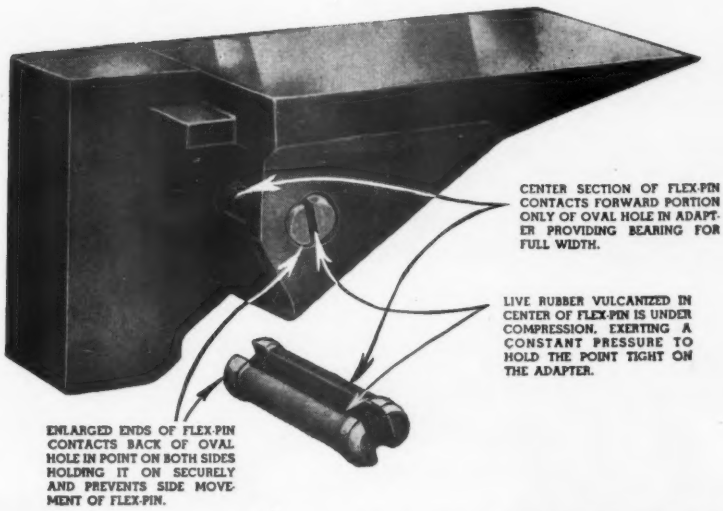
▸ **E. Russell Griffith,** formerly with Ford, Bacon, and Davis, Inc., has joined the AGA staff as research engineer on pipe lines. He is a native of Pennsylvania and a graduate of Virginia Polytechnic Institute.

▸ **B. G. Christopher** of Midland, Texas, and **Larry D. Jackson,** Corsicana, Texas, both of Magnolia Pipe Line Company, have been loaned to the U. S. Defense Department to serve as advisors on construction of pipe line projects in France. Christopher will serve as resident engineer and Jackson as field engineer on construction of the St. Nazaire-Metz products pipe line.

▸ **George H. Rabson,** formerly with Pan American Production Company for 15 years, has been appointed chief reservoir engineer of the gas supply department of Transcontinental Gas Pipe Line Corporation. He is a native of New York and graduate of M.I.T.

▸ **L. E. Jones,** southern district general superintenent for Standard Oil Company of California's pipe line department, has retired as of October 1. His successor will be **E. B. Saunders,** who has been superintendent, southern district, for the past three years. Other personnel changes announced for the pipe line department include **C. L. Reasoner** to succeed Saunders, and **R. R. McGill** to succeed Reasoner as contract superintendent at Los Angeles.

Teeth that really dig


CENTER SECTION OF FLEX-PIN CONTACTS FORWARD PORTION ONLY OF OVAL HOLE IN ADAPTER PROVIDING BEARING FOR FULL WIDTH.
LIVE RUBBER VULCANIZED IN CENTER OF FLEX-PIN IS UNDER COMPRESSION, EXERTING A CONSTANT PRESSURE TO HOLD THE POINT TIGHT ON THE ADAPTER.
ENLARGED ENDS OF FLEX-PIN CONTACTS BACK OF OVAL HOLE IN POINT ON BOTH SIDES HOLDING IT ON SECURELY AND PREVENTS SIDE MOVEMENT OF FLEX-PIN.

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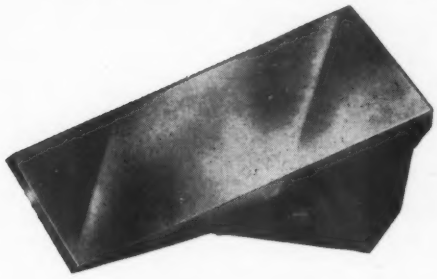

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Examination of longest and oldest continuous mastic application to a product pipe line in the Mid-Continent area . . . after 9 years of service. *(Extracted from "Examination of 335 Miles of Asphalt Mastic Coated Pipe," by Donald E. Miltner, published in July, 1953 Corrosion, publication of the National Association of Corrosion Engineers.)*

"The 335 miles of 6⅝ inch OD pipe line extends from Topeka, Kansas, to Sioux Falls, South Dakota. A lightweight pipe of 14.96 pounds per foot was used in this construction because the line was to be coated in its entirety and in addition maintained under cathodic protection. This weight of pipe was selected to allow an adequate factor of safety for the normal range of operating pressures and yet provide for maximum economy in overall investment costs. Five cathodic protection rectifier units were installed soon after construction of the line was completed.

"The three principal methods used to examine the nine year old coating were:

1. A modified Pearson coating discontinuity survey.
2. Inspection of a representative number of indicated coating failures.
3. Coating conductance measurements on isolated sections of the gross structure.

Results. "This survey indicates that the inspection made of the coating during manufacture and construction of the line was of a high order.

"The rate of discontinuities was found to be one per four miles of pipe line. This exceedingly low rate substantiates the high quality of the coating found in the examination.

"The coating was almost completely unaffected by soil stress with the whitewash largely intact.

"The low discontinuity rate per mile and small area of affected coating shows that moderate protective voltages have not affected the sound coating for at least nine years.

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Conclusion (ours!) 50 square feet of coating adversely affected out of 3 million square feet after nine years is a *remarkable* record!

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A Service Organization Specializing in SOMASTIC Pipe Coating and in the Interior Lining of Pipe by the Tate Process and the Centriline Process.

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—even a complicated one

Selection of the proper grade of stainless steel for a particular application is a relatively complex problem and involves manufacturing, metallurgical, chemical and economic considerations. Although it is complex it has been made easier by industrial research. Data accumulated through years of research and experience gained in helping to solve varied application problems are now available to guide the user in the solution of his present problems.

It is practically impossible to list all the media in which stainless steels will resist corrosion. It is even more difficult to enumerate all the conditions under which the stainless steels will resist effectively the corrosive effects of such media. Frequently, a relatively minor contaminant, when combined with the main reagent, will cause a more detrimental corrosive action than the latter by itself. This is particularly true of iron salts which, in the presence of chlorides, often prove to be a very potent corrodent, producing pitting.

It is always advisable to test a sample under actual operating conditions, especially before extensive untried installations are made. Proper tube selection starts with expert opinion, available to you through Mr. Tubes, your nearby B&W Tube Representative. There is no substitute for the kind of experience with pressure tubing problems you'll find at B&W. Ask Mr. Tubes for help in matching tubes to jobs.

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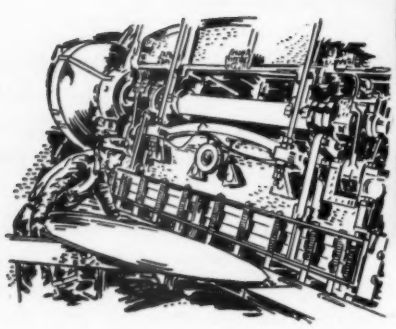

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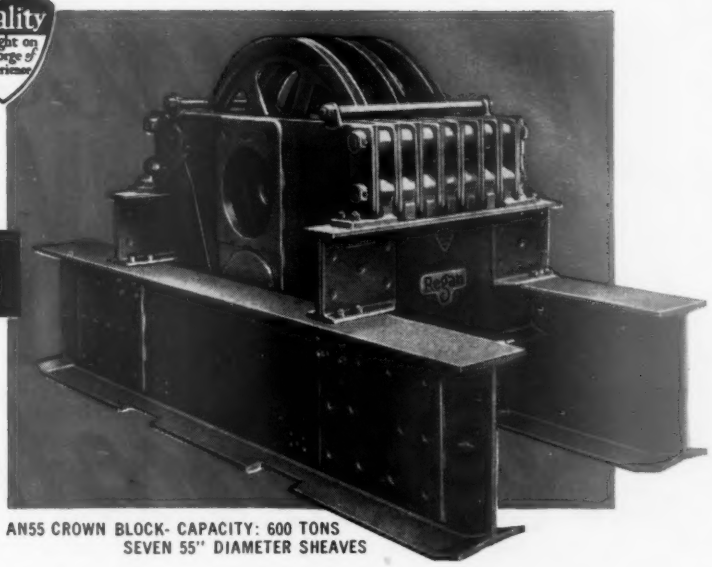

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A 65-foot or 55-foot double leg telescoping pipe mast is available.

FEATURES

CARDWELL air friction clutches in main drum, optional sandline drum and rotary drive.

Transmission provides four-speeds forward and one reverse to both drums.

Free-spooling drums, mounted on double row, self-aligning bearings.

65-foot or 55-foot double leg mast telescopes and folds over the hoist. Mast is raised and extended by line from winch which is driven by truck engine.

K-200 is available with GM 6031-C or Waukesha 145GKU engine, and can be mounted on a WC-2264 White, RF-195 International or 800-Ford truck.

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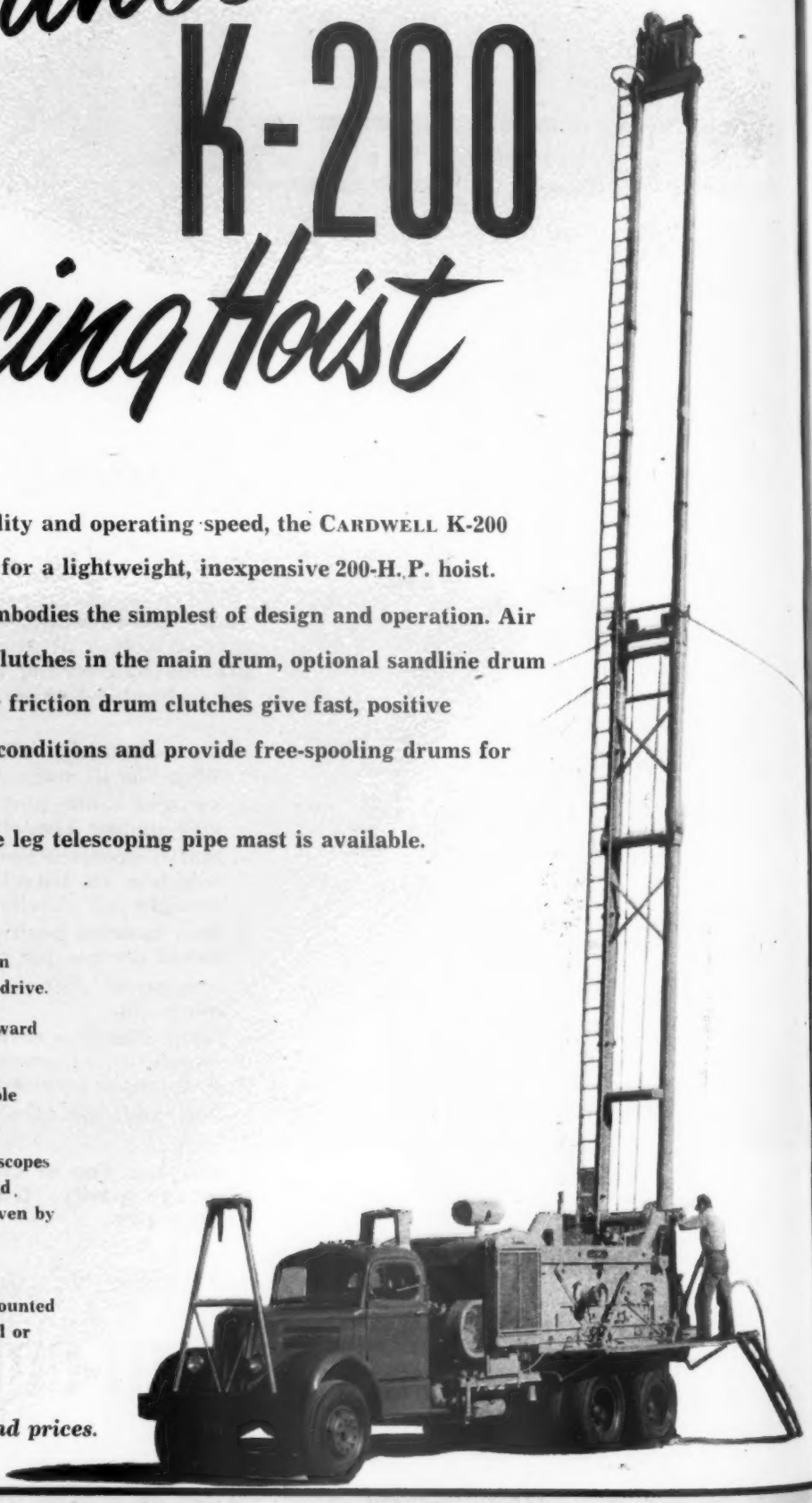

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Bulk Oil Measurement of the Future*

More extensive use of automatic equipment is foreseen for measuring, sampling, and testing

CENSUS experts have estimated that in 1975 the population of the United States will be somewhere between 200,000,000 and 220,000,000. This represents an additional 12,000,000 to 15,000,000 families. If we maintain our present standards for living, education, and recreation, the demands on the nation's resources and facilities for production, transportation, and commerce certainly will increase considerably.

What effect will these demands have on the petroleum industry? It is anticipated that about 60 per cent more automobiles will be on the road, and some of our own API prognosticators predict that there will be about 65 per cent more demand than can be supplied from the present production of about 8,000,000 bbl per day. When this estimate of the future is considered, our expanding industry must plan carefully to cope with more and more problems in the storage and transfer of bulk-oil quantities.

We can be proud of the contemporary achievements in the field of quantity measurement. We can see the gradual perfection and increasing acceptance of meters as a sound basis for measurement. The recent introduction of the "measured-mile" system for the calibration of pipe line meters represents another progressive step for improving the measurement of pipe line throughput quantities.

Tedious tank climbing and manual methods for the determination of gages and temperatures of storage tank quantities are being replaced successfully by the use of automatic measuring devices. Some of these devices indicate an interesting trend toward even more simple measurements by remote control, such as batteries of tanks hooked up to central control panels where liquid-level gages and temperature readings can be obtained at will. These examples of time and money-saving improvements illustrate the progressive developments that have occurred in the measurement of petroleum and petroleum products. For the long pull, these technological developments must pass the test of "return on investment."

*Presented before the American Petroleum Institute, Annual Meeting, Chicago, Illinois, November 8-11, 1954. This paper is one of a symposium, prepared by members of Task Group III, composed of J. H. McClintock (chairman), Esso Standard Oil; A. E. Miller (vice chairman), Sinclair; J. G. Berglund (secretary), Standard Oil Development Company; A. A. Buzzi, Shell; E. L. Hoffman, Socony-Vacuum; L. L. Kennedy, Esso Standard Oil; R. A. Martin, Standard Oil (Ohio); H. L. Shatto, Shell, and L. S. Wrightsman, Humble Pipe Line Company.

Delivery of the paper, on behalf of Task Group III, by J. H. McClintock.

Statement of Basic Principles

Before any discussion of future possibilities it might be well to restate the principles underlying our appraisal of future development:

1. Sound measurement always will be the backbone of proper determination of bulk oil losses and the only firm basis for the establishment of good control.

2. The accuracy and other advantages to be achieved and retained must be the optimum as dictated by economics.

A Look Into the Future

With these principles in mind let us take a look at bulk oil measurements of the future. We must, of necessity, exert more imagination and effort in acceleration of our progress. Visualize what a 65 per cent increase in demand represents. It is almost 5,000,000 bbl, and would fill more than 20,000 tank cars daily. To say that this increased volume will require expanded storage facilities is to state the problem mildly. Perhaps the answer is in larger storage tanks. Perhaps storage plans for the

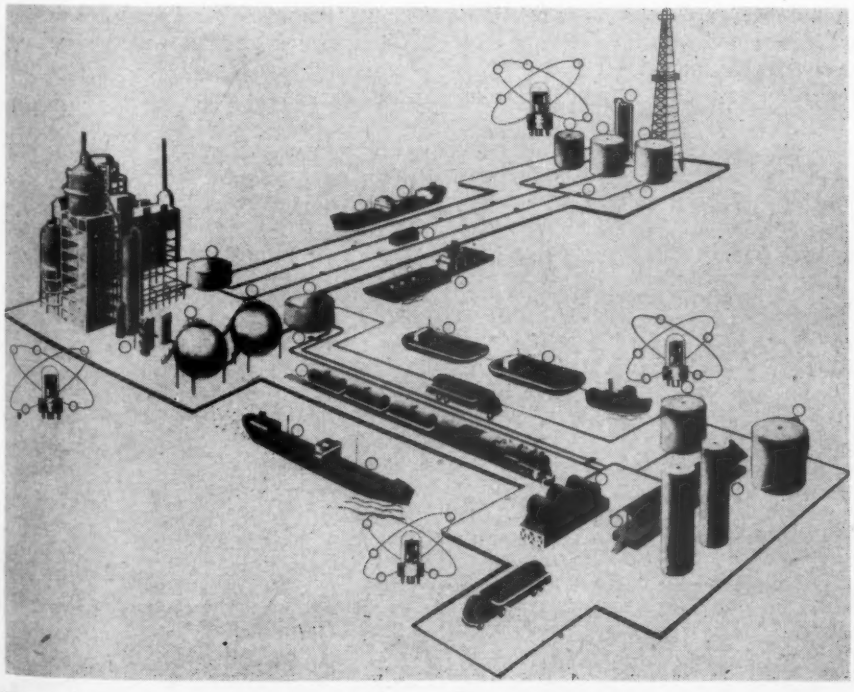

FIG. 1. Tranportation flow chart. Circles indicate where men are required. "Electronic" symbols show where men have been replaced.

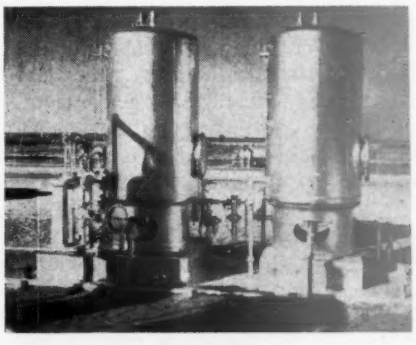

FIG. 2. Crude oil weigh tank.

FIG. 3. Control console of a modern pipe line station.

future will include the use of underground facilities such as the pits and abandoned quarries that have received much study in recent months.

To appear even more radical is to consider how we could aim our efforts toward further automation. Perhaps we should look forward to a nonstop closed system in which the oil moves as a continuous stream from the wells to the refineries as crude oil, and then directly to the point of sale as a refined product. Because dry gas can be piped directly to the consumer, can we look forward to the day when our customers draw their requirements from metered lines at will?

To stir the imagination a bit more, let us consider the possibilities attached to the fact that a presently available remote-control system may be actuated by electronic impulses. You have seen the astonishing versatility of electronics in making factory operations largely automatic, and you know of the developments in electronics for simplification of our office clerical work.

Many types of measurements are now being made by electronic equipment. There is no apparent reason why the entire measurement operation in both crude oil and refined products cannot be made wholly automatic, including the determination of net quantities, the calculation of loss data, the computation of crude oil and gas royalties, the recording of inventory-control statistics, the compilation of yield information, and the other important end uses of the actual measurement. The results of such a development would be the immediate preparation and availability of financial statements and operating statistical reports which are so important to intelligent management.

Another provocative thought involves the basic volumetric units of measure. Are gallons or barrels the best units we can use? After all, bananas, among other things, were once sold by the dozen; now they are sold by the pound. Eggs are retailed by the dozen, but are graded and priced by weight for the wholesale market. We cannot say that there is a potential improvement over the gallon or barrel measure for oil, but we should certainly not close our minds to any ideas, regardless of how radical they may seem.

What Is Being Done?

After the possibilities have been reviewed the logical question is: "What is being done about them?" You should have complete confidence that the problem will be approached with imaginative and aggressive research. The challenge, at least, is being met with a reasonable start in the right direction. All of you are aware of the work which has been done by the Joint ASME-API Committee for Volumeter Research (positive-displacement meter code committee). Then there is the work of the American Society for Testing Materials, and of many committees and divisions of the American Petroleum Institute, leading toward the development and eventual industry acceptance of automatic devices.

Various types of automatic or ground-level gages, which can be equipped for remote reading, already have received wide industry acceptance and may soon be used generally for measurements for custody transfer. Equipment for the automatic measurement and recording of temperature is also available and may soon be used in custody transfer. Other means for measurement of quantities may be in the early stages of development, but they are no less promising.

Work has progressed rapidly in the development of large-size positive-displacement meters, and practical applications have been made. These have obvious advantages and, with automatic temperature compensation, possibly will eliminate the need for thermal correction of volumes. The printed-ticket methods now used for meters may find use in gaging techniques. The remote gaging and temperature-measuring devices may be adapted to print or punch inventory data. Furthermore, the punch card may be useful as an order card, an automatic loading or delivery card, as well as an accounting card, all in one.

Equipment for measurement by counting equal increments of weight is under development to utilize the inherent accuracy of the beam balance. This method eliminates the error that may occur in the determination of temperature and the conversion of volumes to 60 F.

One of the simpler and more conventional means of automatic measurement of quantity for automatic transfer is the counting of runs from a calibrated vessel with fixed "sensing" points for upper and lower levels. This arrangement could be thought of as a very large (for accuracy) positive-displacement meter.

Quality measurement and testing can be improved also either through reliable automatic sampling for subsequent testing for "suspended water and sediment" and gravity or through the use of instruments for determining

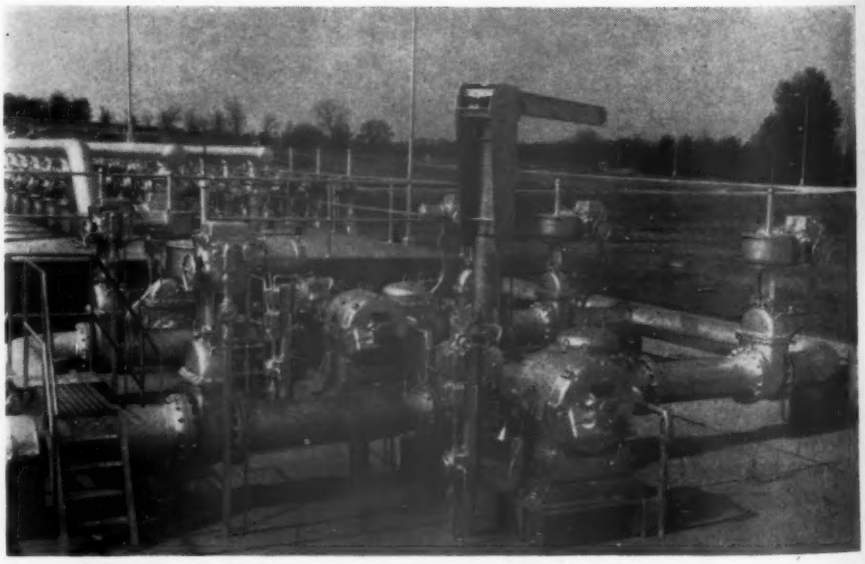

FIG. 4. Pipe line manifold.

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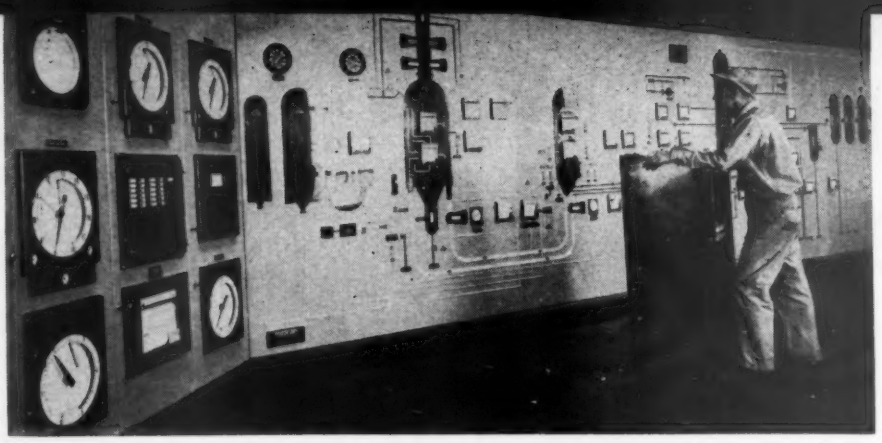


FIG. 5. Modern automatic catalytic cracking plant control room.

these properties directly in a pipe line or tank. Many improved samplers are appearing on the market, and much is being done to evaluate and improve the sampling methods. These improvements involve the location and type of drawoff tube; the integration of sample volume and stream rate; and methods for handling, storing, and testing.

The measurement of gravity without sampling may be done with several instruments that either are available or are under development. These instruments measure density by determining such physical data as force on a displacement element, weight of a unit volume, pressure of a hydrostatic column, and absorption of rays from a radioactive source. The measurement of water and sediment content without sampling is more difficult, but significant headway is being made in the development of a method based on the measurement of dielectric constant.

Inasmuch as control of quality "losses" is being studied to a great extent today, it should be noted that dramatic progress is being made in the development of spectrometric and other analytical instruments which can provide *complete* qualitative analysis of a hydrocarbon stream. In all cases the possibilities are promising for substantial improvement in the accuracy as in the ease and facility of determinations. Most important of all is that progress is being made to make each of these determinations completely automatic.

When reliable automatic measurements become a reality, the way will be open for automatic and centrally controlled transfers. Work is now in progress to develop an acceptable automatic-control system for the measurement and flow of crude oil quantities from lease-tank batteries. Although only small volumes are involved in the application, there are a large number of such batteries, and the results of this work should be applicable, in general, to other industry operations.

Let us consider the practicability of a composite application of these future developments. Certainly improvements in accuracy can be anticipated because of better control. Increased efficiency and manpower savings should result from the simplicity of operation. As these devices find wider use, we can also look forward to the continued improvement in the industry's safety record. If the need for intermediate storage is reduced, some of the present storage problems such as evaporation losses, accumulated sediment, water, flexible bottoms, and the like may be eliminated or at least reduced in importance. In addition, there are the capital savings that also are to be accomplished.

Consider the advantages of a system that has been integrated with an electronic calculator so that measurement can be determined directly on a net-quantity or temperature-corrected basis. The necessity for separate operations to determine liquid level; temperature; and even gravity, water, and sediment may be replaced by a simple push-button operation. Plant inventories may become a one-man one-day job. Other developments, such as automatic pumps and valves, may permit product transfer and control in a bulk terminal to be done by a single operator.

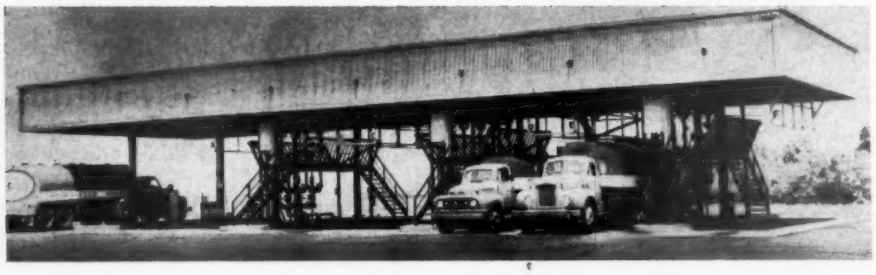
Fig. 1 illustrates the various phases of oil transportation. A number of operations must be carried out in our present practice of bulk-oil measurement each time a transfer of crude oil or product is made.

A large number of men usually is required to perform all of these duties, which involve the following: Tedious and often rugged tank climbing; accurate measurement of the oil and water-and-sediment levels; time-consuming, and sometimes messy, determinations of average oil temperatures; sampling for gravity; water-and-sediment and other tests; and, finally, calculation of the quantity handled.

Our predictions are that these operations will be done automatically in the future, and it was stated previously herein that many such automatic devices actually are available today.

Let us discuss some photographs of a few of today's devices adaptations:

Fig. 2 is a picture of a weight-measuring fluidmeter that is under experimental development for the automatic measurement and automatic custody transfer, or running, of crude oils to a pipe line.



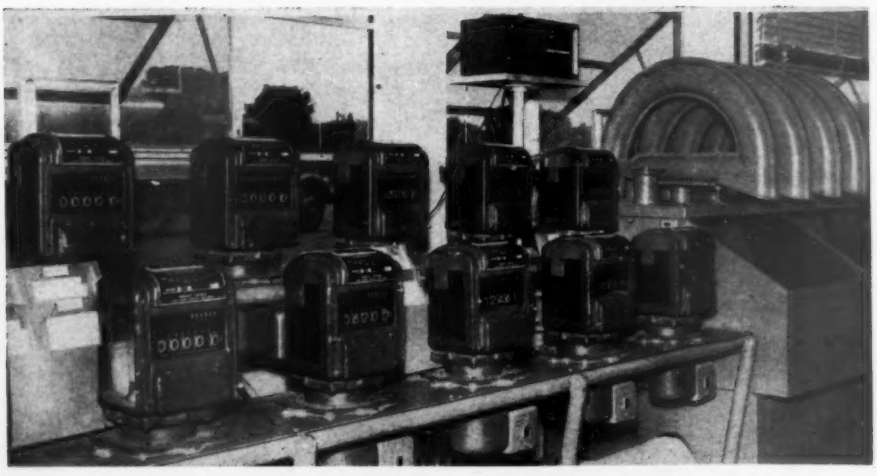


FIG. 6. Truck loading rack and control room of a modern terminal.

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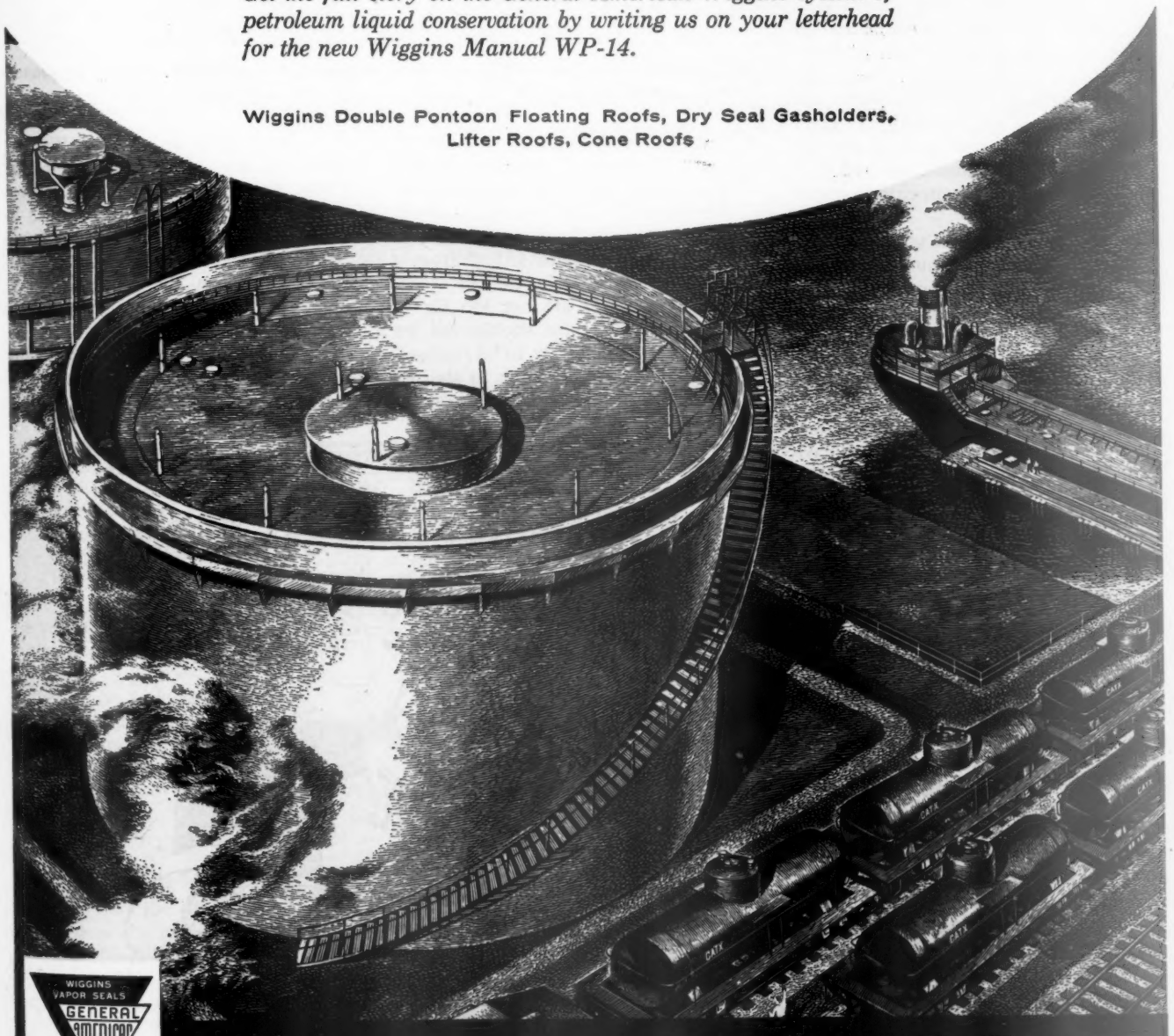

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Fig. 3 is the control board of a modern pipe line station. The entire station can be operated from this graphic console. The motor and pump controls are on the panel at the left. At the right is a schematic diagram of the station manifold with the necessary valve controls incorporated into the console. Meter counters are shown in the background.

Fig. 4 is a view of the manifold with its automatic valves and pumps.

Although the photograph in Fig. 5 of a modern catalytic-cracking-plant control room does not illustrate equipment used exclusively for bulk-oil measurement, it is an excellent example of what can be done in modern instrumentation.

Fig. 6 is a photograph of a modern tank-truck loading rack and its control room.

Mention was made of the advances in devices for testing product quality by automatic means. Fig. 7 is a flow chart that illustrates a possible assembly for quality control. Most of these devices are available today. The graph covers such tests as gravity, water and sediment, flash, and viscosity. On gasolines, such special tests as those for sulfur content, tetraethyl-lead, hydocarbon-air ratio, and hydrocarbon types are possible.

Let us go back to the transportation flow chart showing the number of men required in our present operations (Fig. 1). The installation of automatic equipment can improve the picture considerably (Fig. 1). In the interests of safety, men can be kept off stairways and tanks. Accuracy should be improved because errors resulting from the human element should be reduced —particularly those that are apt to occur during adverse weather conditions. In terms of economy, fewer men will be required to run the plant or, at least, the present manpower resources can be used more efficiently.

All of the operations for measuring, sampling, testing, and custody transfer of crude oils and products may be performed by a few men operating from central control panels.

Fig. 8 is an artist's conception of a central control panel. You will note the televiewers for scanning various sections of the plant and, of course, the maze of buttons and organlike "stops" for obtaining measurements, controlling pumps and valves, and so forth. On the left is an automatic computer. The wide paper tape coming out of the slot on the side of the machine contains the final reports and statements required by management to control operations.

Conclusion

The automatic plant is more efficient and practical. In some cases meters can be installed on pipe lines direct from the refinery, thereby reducing the number of tanks required for terminal storage.

The plant is safer, cleaner, and requires a smaller land parcel, which should be a definite advantage from a real-estate and tax point of view.

Our predictions are not too far in the future, and time should not be wasted if these goals are to be reached. The problems are common to the petroleum industry and can best be solved by a pooling of knowledge. We also must explore the information and know-how that is available from sources outside the industry, such as chemical companies, instrument manufacturers, and certain government agencies. In this way the necessary developments can be accomplished without wasteful duplication of effort. *The time is now*. Let us keep rolling toward a bigger and better petroleum industry. ★ ★ ★

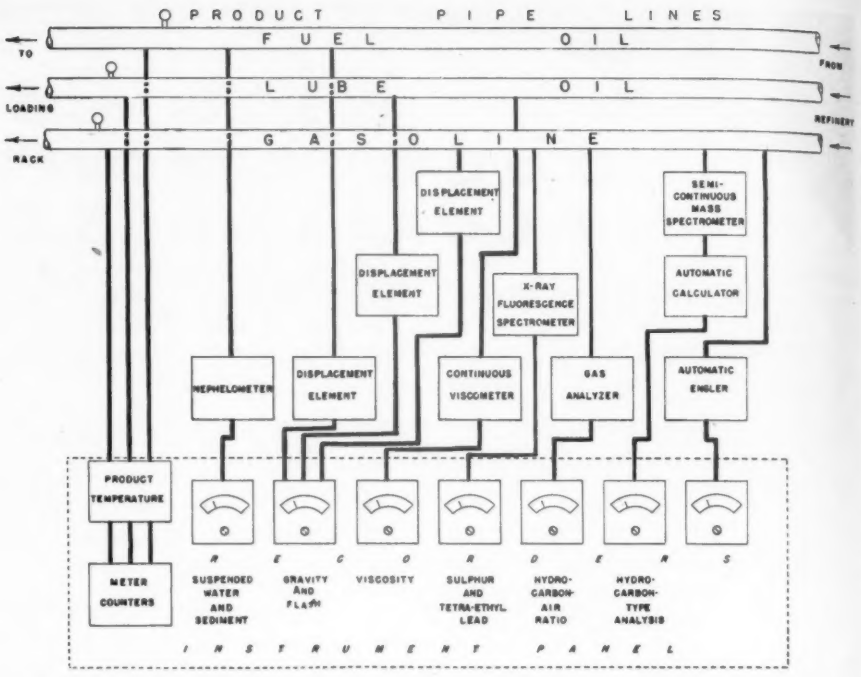


FIG. 7. Flow chart showing battery of instruments for automatic testing of product quality.

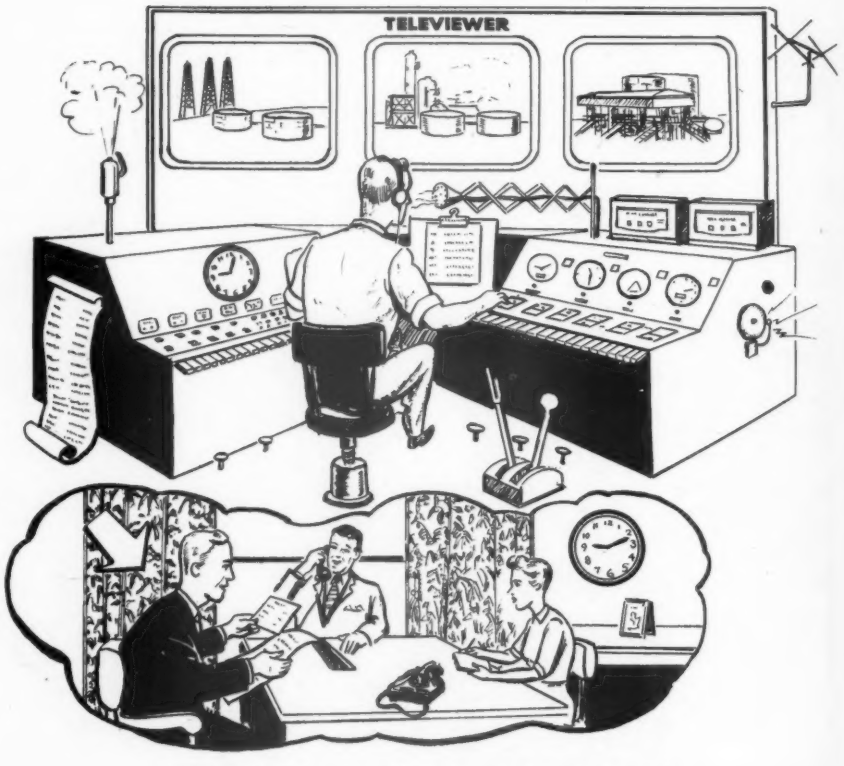
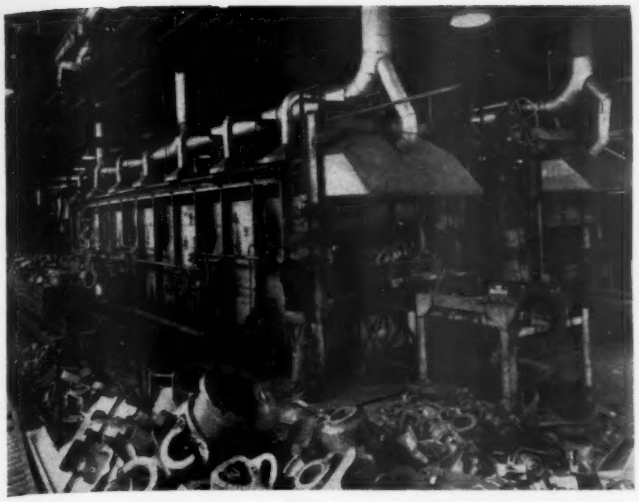


FIG. 8. Artists conception of central control panel.



Continuous heat treating furnace — a practical piece of equipment for normalizing and tempering steel castings weighing up to approximately 100 lb each.

Visual inspection — the inspection level specified in the recommended minimum standard. This operation assures required casting quality for a large portion of steel castings used in the U. S.

Standard for Carbon Steel Castings

Minimum standard recommendations by Steel Founders' Society first in industry's history

A *"Recommended Minimum Standard"* for commercial carbon steel castings, developed by the Steel Founders' Society of America, is ready for distribution to users and producers of steel castings. This is the first minimum standard in the century long history of the steel casting industry.

This standard is the outgrowth of studies made by the S.F.S.A. product development committee and subsequent recommendations calling for its preparation. Succeeding work and its ultimate drafting became the task and the accomplishment of the specifications committee. Thorough discussion in each of the eight society divisions throughout the country focused the practical technology of the entire society's membership into its final composition.

Acceptance of the standard will be voluntary on the part of both the customer and the steel foundry source of castings. It is not expected, nor is it intended that it displace other specifications now in use. It does, however, establish a firm basis by means of which the purchaser and the supplier of general commercial cast-steel components can arrive at a common understanding. It represents a common-sense approach to a fuller use of the properties inherent to cast carbon steel. With this standard the Steel Founders' Society of America goes on record as advocating the purchase and sale of carbon steel castings in a preferable physical and metallurgical condition.

> Steel castings are widely used in the petroleum industry. A partial list of applications includes bit blades, blowout preventor parts, deadline anchors, drilling bits and related equipment, mud pumps, drilling rig parts, pumping equipment, refinery and pipe line fittings, tongs, jaws, latches and protector elements, whipstocks, and cages. Related equipment also finds steel castings in heavy use for such items as diesel engines, winches, derricks, heat exchanger parts, and a variety of pumps and compressor units.

The standard emphasizes that its requirements are minimums and that they are not designed to influence in any way the production of castings that are practical improvements on such minimums. It is intended that all clauses apply unless otherwise agreed upon by producer and customer.

Quality control procedures, primarily in regard to physical and chemical properties, will govern production of steel castings under conditions set forth in the recommended minimum standard. Control of these properties implies a need for similar techniques in the selection of raw materials and the processing steps through the melting and heat-treating cycles.

Quality control procedures are a growing factor in steel casting production. Selection and control of sand properties, selection and use of scrap, relationship of casting size and shape to metal pouring temperatures, required temperatures and treatment for proper alloying, rate of heat input in both melting and heat treating, process inspection, mold cooling cycles, and variations in dimensional shrinkage are a few of the items in a steel foundry that lend themselves to such techniques.

Heat treatment of steel castings is emphasized. The minimum standard recommends either full annealing, single normalizing, or tempering (stress relieving) as desirable treatments. Research reports and literature issued by the Steel Founders' Society have identi-

fied the improved design properties achieved by heat treatment. A machineability research shows that heat treatment improves the machining characteristics of cast steel, an important factor in the cost of metal components.

Note is also made of the desirable practice of supplying a casting drawing along with pattern equipment. Under this condition the foundry assumes the responsibility for checking to insure accurate dimensions in the finished casting. Such action is particularly important when attempting to use equipment originally made for other metals or when wood patterns are stored for periods of time.

The growth and contraction of wood with the seasons is sufficient to throw long dimensions out of line or warp a pattern in such a manner as to create an out-of-shape casting. This fault is particularly true of the so called "inexpensive patterns."

Methods for maintaining specified physical and chemical properties are set forth in the body of the "Standard." Variations in the chemical content are subject to constricting totals designed to give proper metallurgical balance. Inspection requirements as to external quality are at the visual level with dimensional limits checked by gages and fixtures where required.

During the development of the standard several foundries adopted the practices advocated as a basis for their own operation. There will be applications and production, however, where the quality level set forth in this standard is not required. It must be emphasized that the use of this standard is a matter of voluntary agreement between the boundry supplying the steel casting and the buyer.

The creation of this minimum standard is a natural and logical outgrowth of activities within the Steel Founders' Society. Today, some 30 research projects sponsored by the society are published and available to its members. Some portions of these are supplied to customer industries as guides in the use of steel castings. Twelve additional projects are under way and others are contemplated. All of these are directed toward the improvement of steel casting production methods and the metallurgical and physical properties of the various carbon and low alloy cast steels.

Technical and operating conferences in each of the eight divisions of the society are continuously developing the use of information coming out of this research program, as well as providing a medium of free exchange for operating and technical ideas among the steel foundries in a given area.

Paralleling these activities is an active product development program designed to discover new steel casting applications and improve the design of cast steel components. Among the duties of the product development committee are the promotion of casting quality, design, and new products.

The recommended minimum standard becomes one of the first steps in a marketing program now being initiated by the Steel Founders' Society of America. Quality, dependability, and reliability are marketing instruments in themselves. Improved physical and chemical properties constitute another market improving device. The adopted standard promotes these factors. * *

Phillips Joins Atomic Group

Phillips Petroleum Company has announced that it is a member of the recently formed Rocky Mountain Nuclear Power Study Group. Group has been formed to investigate the technical and economic feasibility of a multiple-purpose nuclear reactor for the production of electrical power, fissionable materials, and radioisotopes. Nine companies comprise the group, of which Phillips is the oil company.

Phillips first began atomic energy work four years ago when it was selected to operate the materials testing reactor west of Idaho Falls, Idaho. Company also supervises the Idaho chemical processing plant.

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This new Arcco-Anubis Dry Air Gas Gravitometer determines and records specific gravity of gases automatically corrected to the humidity content of the air. The difference in weight between a column of GAS and equal column of DRY AIR is measured. This ratio represents the true specific gravity of the sample.
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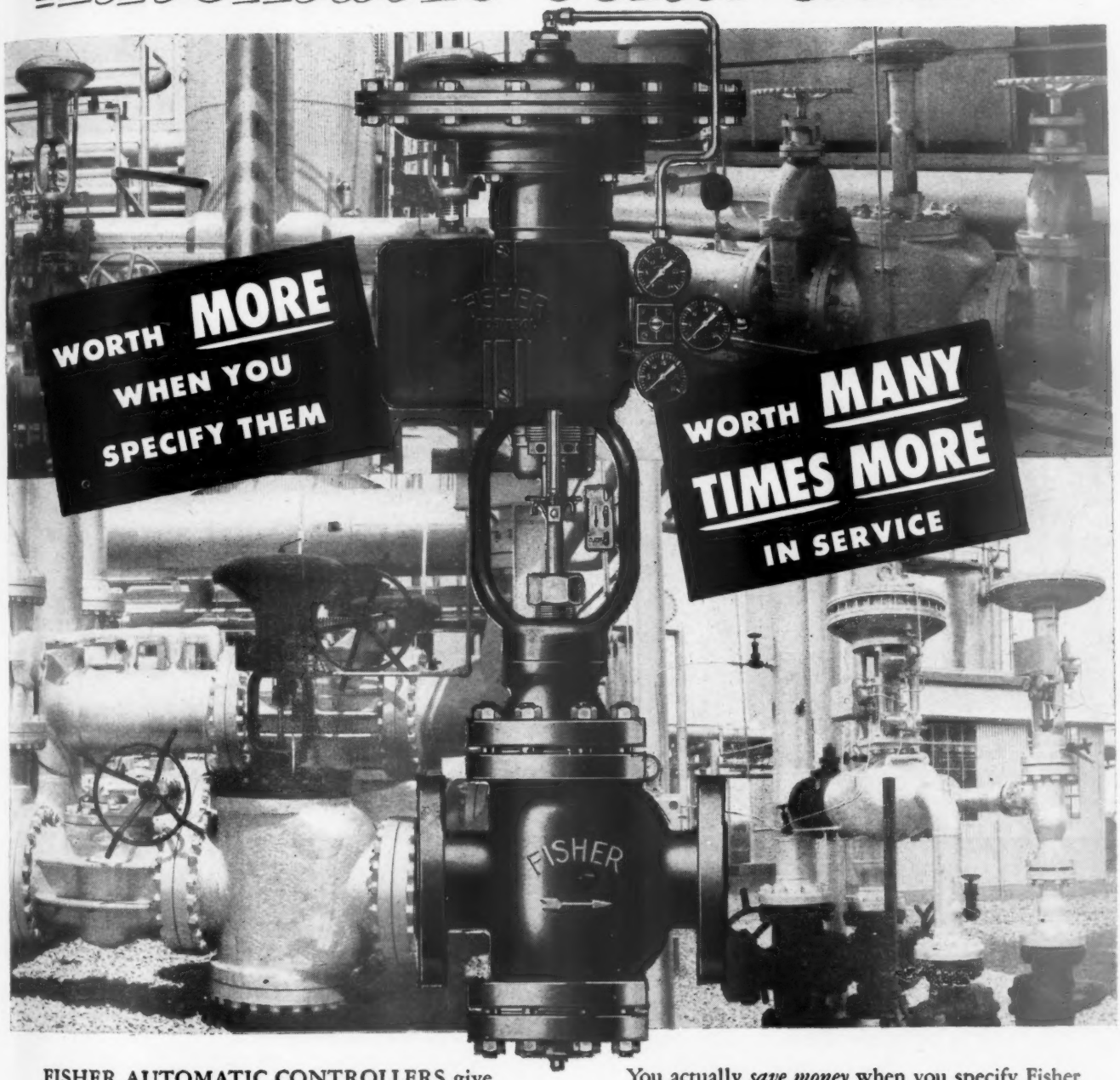

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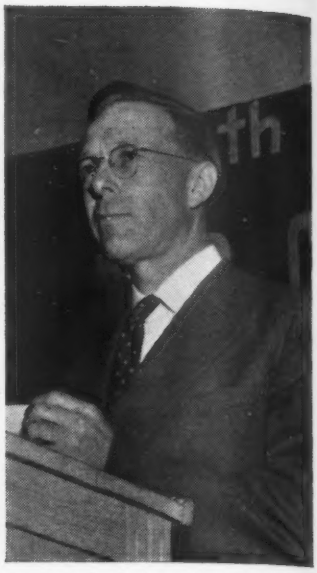
Attention is focused on Senator Lyndon Johnson, a surprise speaker at meeting. Seated are Maston Nixon, president of Southern Minerals Corporation, Edward A. Landreth, Edgar F. Bullard, president of Stanolind, Hines Baker, president of Humble, and Harry Bass, president of Texas Mid Continent Oil and Gas Association.



Premier E. C. Manning of Alberta, Canada, drew laughter and applause comparing Alberta and Texas.

ANNUAL MEETING TEXAS MIDCONTINENT OIL AND GAS ASSOCIATION

Eugene McElvaney, First National Bank, Dallas, and Texas Mid-Continent treasurer; P. C. Spencer, president of Sinclair Oil Corporation and API Chairman of the Board; Charles E. Simons, executive vice president, Texas Mid-Continent Oil and Gas Association.

Chairman Ernest O. Thompson, Texas Railroad Commission; Edgar F. Bullard, who received one of two Distinguished Service Awards at the meeting, and Robert F. Windfohr, president, Mid Continent Oil and Gas Association. Thompson introduced Admiral Radford, who spoke at the 35th annual meeting.

Ed Gossett, former congressman and general attorney of Southwestern Bell Telephone Company, presents President Harry W. Bass with a copy of "The President's Prayer" as an award to the Texas Mid Continent for aid to the U. S. Savings Bond program.

John W. Wagner, director of association public relations, presents an "Assignment of Braggin' Interest in an Oil and Gas Lease" to guests at the dinner for the press at the Plaza Hotel.

Admiral Arthur Radford, chairman of the Joint Chiefs of Staffs, talked on "Evolution of Military Strength for the Long Pull."

XUM

See why FAST'S Couplings are your wisest buy

LESS DOWN-TIME. Industry finds that Fast's Couplings, the original gear type coupling, give trouble-free performance. They save on maintenance. Save money (often thousands of dollars in production losses) year in, year out, because there is no down-time due to breakage . . . no expense of replacing perishable parts.

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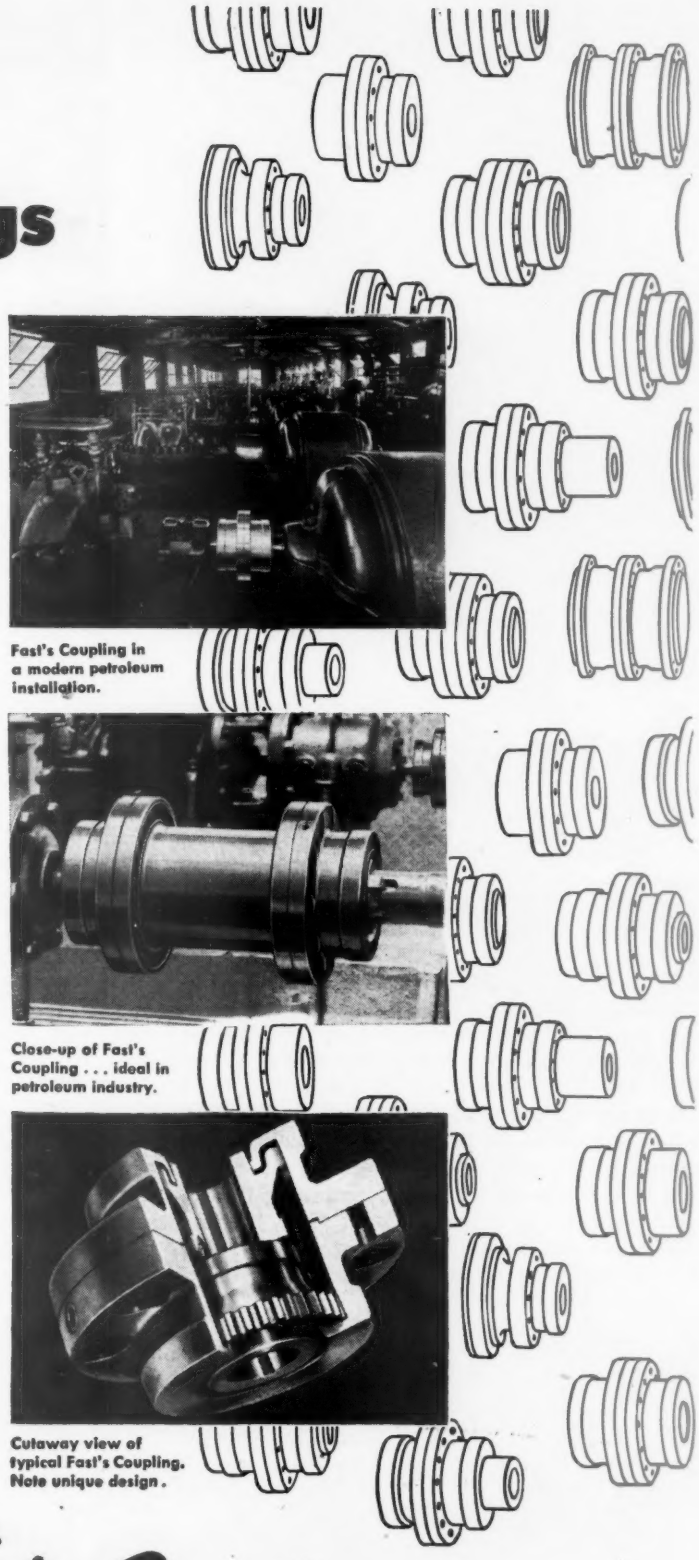

Fast's Coupling in a modern petroleum installation.

Close-up of Fast's Coupling . . . ideal in petroleum industry.

Cutaway view of typical Fast's Coupling. Note unique design.

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FAST'S Couplings

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METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

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Company .....

Address .....

City ..... Zone ..... State .....

To obtain more information on products advertised see page E-59

James E. Mizell, Chamber of Commerce president, and T. S. Petersen, Standard of California's president.

James E. Mizell presents Jules E. Toussaint, Standard's vice president, with plaque marking Standard's 75th anniversary.

CITY PAYS TRIBUTE TO OIL COMPANY

Taft, California honors Standard Oil Company of California on its 75th anniversary

IN an unprecedented gesture of goodwill and appreciation, the city of Taft, in Kern County, California, played host to the Standard Oil Company of California on the occasion of the latter's 75th anniversary, September 9, 1954.

It was fitting that the 75th birthday of the Standard Oil Company of California should be primarily observed in Kern County, because the progress of the company and the progress of Kern County have been closely associated in the three-quarters of century since the founding of the petroleum concern. (Taft is the home of Camp 11-C, headquarters of the company's San Joaquin Valley producing area).

Taft made the occasion one of civic celebration, and the high officials of the company joined with the civic officials and leaders of Taft and surrounding communities, to honor the concern that has figured so highly in the steady economic and social growth of the city and county.

In commenting, at a luncheon address, T. S. Petersen, president of Standard Oil Company of California, stated, in essence, that "the primary job of a corporation of our size and substance is to sell the communities in which we reside on the scope and integrity of our purpose." The community spirit displayed in Taft in honoring Standard Oil Company of California on this occasion was resounding testimony of this job, well done.

"Old Times" parade at Taft's celebration.

Taft's Desk and Derrick members serve barbecue.

SLURRY OIL SQUEEZE

New DOWELL SERVICE is designed to control water production in oil and gas wells

SOS* (Slurry Oil Squeeze) is a new Dowell cementing service designed to stop undesirable water production quickly. It has proven highly effective in both oil and gas wells in almost every type of formation.

The slurry used in SOS consists of portland cement, a special Dowell surface tension reducing agent, and a non-aqueous carrying medium like diesel oil or kerosene. The cement will not set up in the presence of the non-aqueous carrying medium or the crude oil contacted in the pay. It will readily set up when contacted by formation water.

The entire batch of SOS slurry is pre-mixed in truck-mounted, paddle-mixing tanks. This method provides a smooth oil-cement slurry of any density the operator desires. Then high-pressure, triplex pumps are used to inject the slurry into the formation.

Here's proof that SOS pays off! Dowell engineers were called when a well tested several hundred barrels of salt water daily, with only a trace of oil. After SOS, the well produced 40 BOPD and no water. Another well was producing 30 BOPD and 30 BWPD. An SOS treatment stopped all water production. The well still made 30 BOPD.

For full information on Slurry Oil Squeeze call your nearest Dowell office or write DOWELL INCORPORATED, Tulsa 1, Oklahoma, Dept. K-12.

**A Service Mark of Dowell Incorporated*

services for the oil industry

DOWELL

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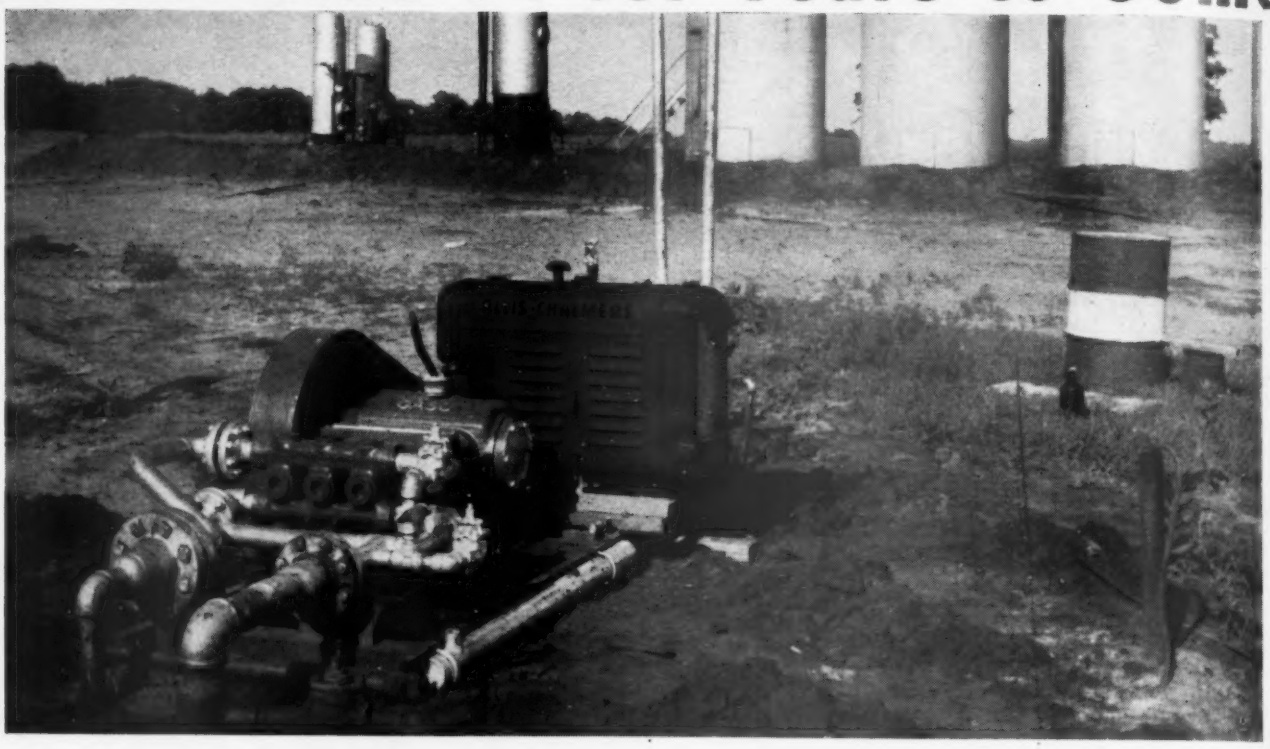
On the Line . . for Years to Come



ALLIS-CHALMERS ENGINES will deliver dependable-economical Power

WHY

The first cost is lower—not one competitive engine with all the features of Allis-Chalmers Engines and comparable in cubic inch displacement is so low in first cost.

and WHAT are THESE FEATURES

Valve in head—removable wet cylinder sleeves, large capacity, high turbulent cooling for stationary work—oil pressure lubrication at any speed—enough metal in block to prevent warping and misalignment of working parts—rated output developed at medium speeds.

AND

When the day for repairs comes along as it surely will on any engine, compare the cost of crank shaft, water pumps, cylinder kits, blocks and other replacement parts with any other engine—You'll be surprised at the low cost.

Allis-Chalmers Engines are heavy and rugged, they're built to give long service on the toughest jobs.

COMPARE

1. Allis-Chalmers Quality
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With those of any other engine

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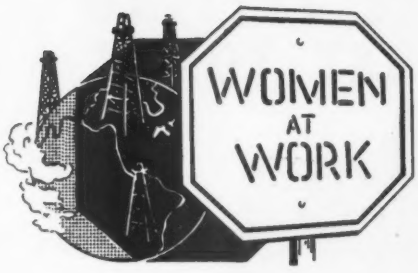

Oil Captivates Singer

A concert singer becoming an independent oil and gas operator may seem paradoxical, but Lucille H. Pipkin's successful Pictured Cliffs gas wells in the San Juan Basin of New Mexico have made her an "oil operator."

Her first gas wells, at the northwest corner of the Huerfano Mountain on the 63,000 acre Huerfano Unit, are in an area where previous drilling had shown little promise.

The Lucille Pipkin well No. 1 was a big suprise to everyone and the vibrant applause on a concert's opening night had never afforded a greater thrill for Lucille. The electric log was discouraging, but a drillstem test from 2110-2195 ft brought gas to the surface in 4 minutes. Pictured Cliffs wells are shallow, the No. 1, 2195 ft, and No. 2, 2234 ft. Initial potential of No. 2 well is 2,300,000 cu ft of gas per day.

Three days before Christmas, Lucille opened up a new field with a 776 ft Pictured Cliffs well, probably the shallowest in San Juan Basin, for initial potential of 600,000 cu ft per day.

Miss Pipkin drilled all the wells on her own, using her own funds, and staking the first well herself. Her father, Eugene H. Pipkin, has been in the oil business since 1905; and since he provided the example Lucille says she is doing what comes naturally.

The family, prominent residents of Roswell, holds a quarter of a million acres of leases in New Mexico and Utah.

Prior to entering the oil business, Miss Pipkin attended Amarillo Junior College, the Boston Conservatory of Music, and spent 9 years on the West Coast studying voice and appearing in concerts. A native Tennesseean, she has a lyrical speaking voice, complete with southern accent.

Concerning her present career, Miss Pipkin is firmly convinced that her interest is in the oil industry, with a slight leaning towards uranium! She says, "The San Juan Basin is fascinating, fantastic and fabulous."

Lucille Pipkin operates in San Juan.

West Texas Geologist

Most people visit Niagara Falls for romantic reasons, but Kathleen Keathley went to get a rock to add to her collection. She got it, too—edging down to the rim of the falls while her mother almost had apoplexy.

Kathleen is an independent consulting geologist in Midland, Texas. Her husband, Marshall, is a geologist too—with Forest Oil Corporation.

Since she can remember, Kathleen has been collecting rocks, but she had not considered a career along these lines. She almost became a school teacher before she changed her major,

Rock collecting led to career.

in her junior year at Southern Methodist University, to minerology.

Her name was inscribed on a bachelors from SMU and a masters degree (from the University of Missouri — where women could go on the necessary field trips to get such a degree) before she joined Standard of Texas at Midland in 1943.

Kathleen was a bride of four months when her husband sailed for Europe to join in the Normandy landing. She took up a career in petroleum geology, holding positions with Sun Oil Company and Republic Natural Gas. In 1946 she joined the teaching staff at SMU and did consulting on the side. In 1951 she became a full-time consultant.

Her career, her husband and their new home could be a full life for Kathleen, but she is a superb cook and a proficient gardener. She collects antiques and demitasses, plays the piano, paints in watercolors and does woodcarvings. She rides, swims, and fishes. But her favorite hobby is still her rock collecting.

Bowling is one of Eleanor's many hobbies.

Beauty and the Brain

It's a wonder that Hollywood hasn't swiped pretty Eleanor Hutchison long before now. It might have, too, if Eleanor hadn't been as partial to her job at General Petroleum Corporation as it is to her.

Movie stars have nothing on her in looks, and certainly nothing in brains for Eleanor solves simultaneous equations involving the relative masses of light hydrocarbons in refinery processing streams for the Torrance Laboratory of General Petroleum. She's been handling the job for ten years and her co-workers say she's so good that she can tell by looking at a sample whether it differs from the standard.

Eleanor came by her job naturally enough. She can number half a dozen male relatives, including father and brother, who are in the oil business. It was her brother, in fact, who is responsible for her having this job. General Petroleum was one of the first companies in the nation to have a mass spectrometer, a giant machine that sorts out various gases in the sample electronically, measures them, and records them on a chart. When the machine arrived, a girl technician came along to instruct the lab men in its use.

If any girl could operate that machine, William Hutchison reasoned, it was his pretty sister who had studied mathematics at Compton Junior College. All he had to do was sell the company on the girl and the girl on the job. He did, and Eleanor left her bank job to get on the petroleum bandwagon.

Not all of Eleanor's time is spent computing mathematical formulae. She is an avid sportswoman, being particularly fond of ice skating, water skiing, bowling and dancing. She owns and expertly uses a movie camera. She's a member of the Long Beach Desk & Derrick Club and past officer of two Masonic groups.

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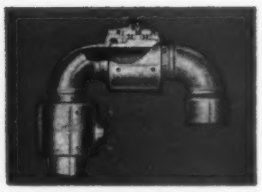

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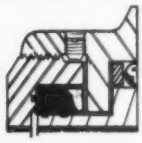

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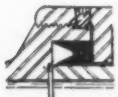

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Compare EMSCO ball race design — thrust bearings for thrust loads. Compare the method of sealing against leakage—an isolated packing chamber in which is retained the type of packing most suited to the job. Fitting breaks like a union for easy inspection or replacement of packing.

You profit directly from these features — the result of years of engineering know-how built into every EMSCO fitting. If you're not already using EMSCO, better send today for latest catalog and prices.

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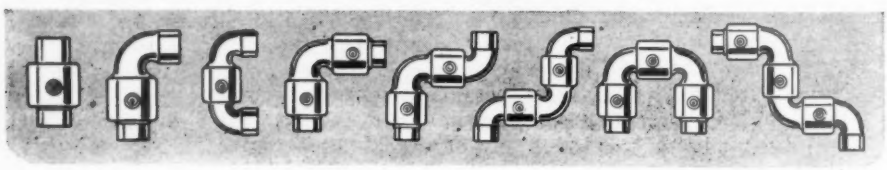


Women at Work

Mrs. Vold is studying in Holland.

Colloidal Chemist

Marjorie Vold says that her favorite hobby is "just loafing," but how, if ever, she finds time to indulge in it is a mystery to all who know her. She is a chemist, studying this year in the Netherlands at van 't Hoff Laboratory. A Guggenheim fellowship gave her the chance to do this work under Professor J. Th. G. Overbeek in van der Waals forces between colloidal particles. From 1942-1946 Marjorie was with Union Oil Company where she worked closely with her chemist husband, Robert Vold.

Mrs. Vold got interested in chemistry by accident. "I got stuck one day with absolutely nothing to read except my high school chemistry textbook. By the end of the day I knew I'd never find more interesting reading material — and my life's work was laid out for me. I never regretted my decision."

Parents and grandparents in astronomical research laid the foundation for Marjorie's insatiable curiosity in science. She graduated from the University of California as valedictorian in 1934, took her PhD in May 1936 and a husband the next month.

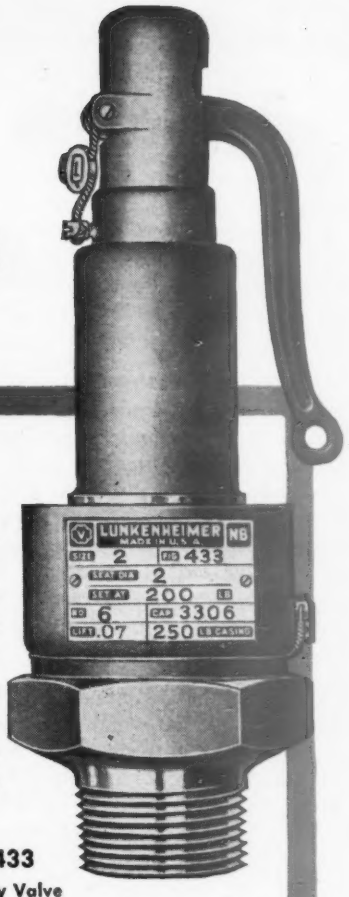
Dr. Vold says she set out to be a model housewife but she and her husband both soon knew that she could not escape from the career she loved. Eighteen years and three children later they are convinced that they were right.

She is a full-time career woman as well as wife and mother, "and there is time for all of it. Both my husband and I greatly enjoy our two daughters and our son. There's just one word of advice on this career-marriage business," adds Mrs. Vold. "Marry someone who shares your interests."

Majorie feels "very strongly that fundamental studies of the origin and behavior of substances should be carried out in a university laboratory."

What else does this "loafer" do? Well, she hikes, swims, teaches Sunday School, works with Cub Scouts, and loves photography and music.

Quality...
where you need it most



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POP SAFETY and RELIEF VALVES

Abnormal overpressures are dangerous in any vessel — boiler, compressor, engine cylinder, or pump. That's why you need *outstanding* quality in Pop Safety or Relief Valves that keep overpressures from developing. Not only are they important in preventing interruptions of service — but they may save lives and damage to expensive equipment. That's why it pays to insist on *Lunkenheimer quality* when you specify or buy Pop Safety and Relief Valves for any service. Lunkenheimer design, materials, and workmanship are world-famous for excellence. Their record of performance is unsurpassed.

Fig. 433
Pop Safety Valve

THE DIFFERENCE BETWEEN POP SAFETY AND RELIEF VALVES

Pop Safety Valves are used in conjunction with gases, including steam. They pop wide open when the set pressure is reached, stay open until pressure has dropped . . . then snap shut instantly. **Relief Valves** are used in conjunction with liquids. They start to open at the set pressure but require about 20% overpressure to open wide. As pressure drops, they start to close and shut tight when the set pressure has been reached.

Fig. 658
Relief Valve

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Application of Company-Developed Standards†

W. L. JAMES*

Abstract

Economy, efficiency, and safety are the basic factors underlying Stanolind Oil and Gas Company's standardization program. The program is applied to two levels of operation: 1, design or layout facilities; and, 2, equipment. As an effective aid in promoting economics, "The Standards Manual" lists all the company's standards from which all references are made.

THE dictionary defines the term "standard" as that which is set up and established by authority as a rule for the measurement of quantity, weight, extent, value, or quality. In a highly industrialized society standardization is a necessity, otherwise the variations in material specifications that would accrue as a result of each individual organization attempting to translate its requirements into written description would be of such volume as to actually stifle industry. The work and cooperation of the 92 organizations and 2000 company members of the American Standards Association have made remarkable progress since 1918 toward simplification of the problem of defining various common denominators of paramount import to industry; however, their work has only begun.

More familiar to us here, is the standardization work ever continuing as a definite part of the API program. This standardization work dates back to 1923 when the board of directors authorized the appointment of several committees to develop recommendations on such subjects as rig irons, cable tool joints, rotary tool joints, wire rope, belting, rigs and derricks, and other items. Subsequently, in recognition of the true importance of such work, API authorized the creation of the Division of Standardization.

It is also to be recalled that the Purchasing Agents Association of Tulsa in 1919 appointed a committee to study the possibility of standardizing rig irons and at about the same time, the Mid-Continent Oil and Gas Association appointed a committee to prepare specifications on oil country tubular goods.

†Paper presented before the Oil-Company Buyers' Group during the 33rd annual meeting of the American Petroleum Institute, in the Conrad Hilton Hotel, Chicago, Illinois, November 10, 1953.

*Stanolind Oil and Gas Co., Tulsa, Oklahoma.

Facts Should Indicate Standards

It has been said that standardization brings economics in proportion to the wisdom with which it is applied and nothing should be standardized merely for the sake of standardizing. Some things are so tangible with regard to standardizing as to become so more or less automatically; others present complications which obviously make it difficult to perceive and equally as difficult to develop into and apply standards. The premise on which the American Standards Association operates is that standards should be developed and published only when the preliminary facts indicate that such standardization will result in important economics or will simplify and clarify operations or safeguard persons and property from injury.

Some five or six years ago Stanolind Oil and Gas Company, recognizing that this premise would apply not only to sizes of nuts and bolts, and on grades of steel as had been developed under the auspices of the ASA, but it could as well apply to operations in our commany. It accordingly launched a program to effect standards on two levels: (1) design or layout of facilities and (2) equipment.

Instituting a standards program, we found, requires traveling a somewhat rocky road with regard to both company personnel and sources of supply. Here and there among company personnel, a feeling of suspicion crops out that they are to become automatons operating from a book of standards, leaving no room for self expression on their part with regard to new ideas and taking no advantage of future new offerings or developments by suppliers. Apparently this suspicion or antagonism, as the case may be, stems initially from a lack of understanding of exactly what is meant by standardization and once the definition is understood and the program made clear, most of the fear is dispelled. To accomplish a standards program that is applicable to an oil producing company such as ours, the various personnel play a vital part in developing all of the information required to arrive at the standards.

Initially, it is necessary to decide on what level to standardize; that is, shall we set up for standards just the barest essentials and the cheapest product and easiest way of doing something — or are we to go all out and develop extremely fancy standards complete with all of the gingerbread? Obviously, either of these extremes could be applied or any of the points in between, therefore the question of a proper procedure to be followed in arriving at the desired level is essential. The procedure in our company is a somewhat lengthy one, though we feel it pays dividends from more than one angle.

Committee Studies Subject

We have a Standardization Committee composed of representatives of the Operating, Engineering, Accounting, Safety, Purchasing and Material Departments in the General Office plus representatives from each division Office. When a subject is up for consideration a questionnaire is prepared and submitted by the committee to all divisions, districts, and field locations for information, comment, and recommendations. After the replies are all in, they are analyzed, the information tabulated and finally presented to the committee for study. Any other members of the company who have a vital interest in the subject are privileged to sit in on the deliberations. From the meeting a recommended company standard is developed and presented to management. In short, on any subject up for consideration, by means of written reports and personal discussion, a balance is sought with regard to safety, efficiency, and economy by digesting recommendations and comments of operating and administrative personnel. This is then presented to management for approval or arbitration. By applying such a detailed routine, the man in the field has an integral part in developing the standard and his apprehensions are further allayed as to the ultimate meaning of the standards program.

Once the standard has been arrived at, the next problem to consider is to decide how rigid or how flexible it

should be. Inasmuch as the type of standards we are dealing with in most cases cannot be adapted to a rigid plan, some degree of flexibility must accompany the program.

New Equipment Tested

To issue a standard and subsequently leave the field wide open would defeat the program. Likewise to confine the degree of flexibility too closely would also defeat the basic premise behind standardization. We therefore handle the problem in two ways. When an exception or change to existing standards on design or layout of facilities is desired, a letter requesting such is directed to the chairman of the study group for consideration. If the idea has merit, the change can be effected at a meeting or by petition to all concerned in the company. Equipment standards, however, are somewhat more rigid and in order that the company may be certain that some new product is not by-passed because of this, a procedure for testing new equipment is available as an avenue for considering such items. The test procedure is not an integral part of the standards program since it has other applications, but it is the principal way to present something new for consideration.

In order that company standards will serve as an important management tool for effecting economics, the various standards are printed and submitted in bound form to all offices within the company on which the standards have a bearing. The Standards Manual then becomes a workable part of the program. The man in the field formerly was required to sit down, either by himself or with a representative of some supply house, and start from scratch to design a christmas tree asembly for instance. Inasmuch as an infinite variety of designs could be worked out from the numerous items and makes of equipment available, the problem at that level was usually solved the simple way, by using the first things at hand or mentioned by some one supplier or by duplicating some other company's practice down the road on the next lease. Actually, sound engineering did go into most of our trees and in some cases the engineering was a little too sound; by that I mean that more equipment than was necessary was used just to make sure. To point up what we mean here, prior to standardizing, we had some 58 different types of christmas trees in use. Our present standards call for 3 basic types with 5 variations of these types. This represents a tremendous reduction and certainly simplifies records, requisitioning, and purchasing.

Other examples of standards that we have developed of the design or layout class include blow-out preventer assemblies, tank batteries, fencing, pulling units, work trucks, and numerous items of a minor nature such as well and lease identification signs, painting, wire rope, etc.

We are exceptionally proud of our tank battery standards. The utilization of these standards is very simple. The standard as contained in the book is in an evolutionary form. Actually, it consists of a set of drawings and bills of material beginning with a drawing and bill of material for one flowing well and progressing by separate drawings and bills of material to cover two and more wells and pumping wells and wells producing water and requiring treaters, etc. As each step is reached in the evolution of a lease, to expand the tank battery facilities simply means referring to the drawings for installation and to the bills of material to determine quickly and economically what to supply from stock and what to requisition.

Earlier in this commentary I made mention of one extreme of standardization — that of the fancy item complete with all the gingerbread. We have two such items, the pulling unit and the standard work truck. The pulling unit has everything but an automatic weather forecaster on it and I'm not sure but what there might be one of those hidden somewhere if you looked hard enough. The work truck, in my opinion, would serve equally as well as a limousine for ex-King Farouk as for field service. Actually, both items represent a considerable amount of design work and both can be classed as special, inasmuch as neither can be found in any manufacturer's standard line of equipment. However, everything embodied in these two units is justified for efficient and safe operation, which is the sort of thing that we are striving for.

Engineering Analysis Used

The other type of standard, that of actual equipment, is not arrived at quite so easily as the design standards. Once again, these standards are arrived at more or less in the same fashion as design standards but in addition policy and price consideration play a paramount role in the selection. The basis on which this type of standard is established is by an engineering analysis of existing equipment available for the item. The analysis is presented in the fairest way possible. Seldom is a theoretical item designed and then all available items balanced against this; rather, complete information is collected from each manufacturer and then each item of equipment is compared to the other and thus we arrive at some order of preference.

This sort of basis, coupled with estimated company requirements, gives considerable freedom to the purchasing function in developing and utilizing quantity discounts from various suppliers, as well as giving considerable latitude in developing more than one or two competent sources for the material. In this type of standard you would find we have neither selected the cheapest nor the most expensive item, but the unit that most nearly embodies the considerations of safety, efficiency, and economy.

Fewer Records Required

The primary accomplishment that we have achieved in this type of standard is uniformity and a reduction of records required on items of equipment. As an example, one type of pumping unit that formerly was used could be purchased with five different and special base extensions, each to accommodate a different type of prime mover. All variations of this particular unit were described solely by a single model number of the manufacturer and it was therefore impossible to tell from the records which type extension was included as a part of the unit. In future years and on subsequent transfer of the unit to another property, this would present quite a problem: First in keeping records as to which type of extension is on the unit and, second, in obtaining a different extension some 12 to 15 years in the future to accommodate a different type of power unit.

As a result of close cooperation between our company and the supplier, an improved base extension was developed that subsequently became a "standard" with both companies. The improved extension will accommodate any of the five prime movers formerly requiring different extensions. This simplifies the record-keeping problem and will preclude expensive field alterations at some future date in adapting the extension to accommodate another engine if the unit is transferred. This is important when you consider that in our company we reach a figure of 45 per cent re-utilization of pumping units; that is, approximately 45 per cent of all pumping equipment installed each year represents a transfer from one location to another. This figure represents two types of transfers, (1) used units from abandoned leases or (2) new units that have been stocked as a result of volume buying for maximum discount.

The logical question at this point is, have we been able to evaluate savings or what method do we use to evaluate the results of standardization. As with most companies, we believe the cost

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accounting required to evaluate standards would be nearly impossible to set up, or the evaluation might cost more than the exact knowledge is worth. However, intangible benefits do have a similarity to tangible costs and we have accomplished a number of steps that certainly have a tangible value, though in themselves are intangible.

We are approaching uniformity in design layouts whether it be in northern Wyoming or southern Louisiana; we are reducing the records required to be kept; we are simplifying the engineering and purchasing work in obtaining materials; we are providing for better dissemination of ideas and knowledge contained within the personnel and streamlining the material problem in our company. Within purchasing proper, we have received a wider latitude on which to negotiate; we have been able to streamline the purchasing transaction; a reduction in processing time has been effected, and probably most important, purchasing actually has had the opportunity of hand in glove cooperation with other units of the company with which it otherwise might not have had any contact except on a purely impersonal plane due to a large organization.

To close this commentary, I would like to touch on a subject that is ripe (and has been for some years) for close cooperation between users and vendors with regard to simplification by standardizing. I am referring to sub-surface or bottom hole sucker rod pumps. In our standards program, this subject was shelved until recently as an expediency. From the beginning it was realized that no little effort would be required to bring any kind of order out of the chaos and confusion surrounding it. Bottom-hole pumps start out innocently enough as being only 5 basic API types. From this, a survey will show over 1000 variations on the market and, incidentally, a result of a study of our own operations indicated we were giving them all a try. This study disclosed a total of 962 different pumps in operation. The ordering of pumps was so confusing that sometimes verbal purchase orders were issued and the vendor would work out the requirements with field personnel and actual orders were not written to cover until we would receive the delivery ticket from the supplier. This I realize, as will you, is an extremely poor way to practice purchasing. Our only excuse is — how could we buy something when actually we ourselves did not know exactly what we wanted?

As a result of cooperation between engineering and the field offices, the 962 pumps have now been reduced to 182 different units and data on these units are now in the process of being published for use in ordering.

The problem, however, is still to be solved and to simplify the situation would involve a concerted effort on the part of the using companies, API, and manufacturers. It is a problem that cannot be simply dumped in the lap of the supplier for we ourselves are to blame for the involved situation. By that I mean, if we did not go into the suppliers store and demand these variations, they just naturally wouldn't exist. A good many of the variations that make up the confusing number of units consist of different fits, lengths, etc. The whole picture can be simplified and resultant savings passed along to the user. Actually, talking with suppliers of this class of material brings out some situations that are ludicrous. You will find that they feel obligated to stock as many as 3500 to 4500 parts and these are not ample to provide for the variety of fits that may be specified. One supplier told me that his company in auditing its parts book found in several cases that an identical part was carried under 3 or 4 numbers.

A concerted effort toward simplification and standardization of bottom-hole pumps would surely pay dividends to both supplier and user and the oil buyers group could well afford to give thought to such a project. * * *

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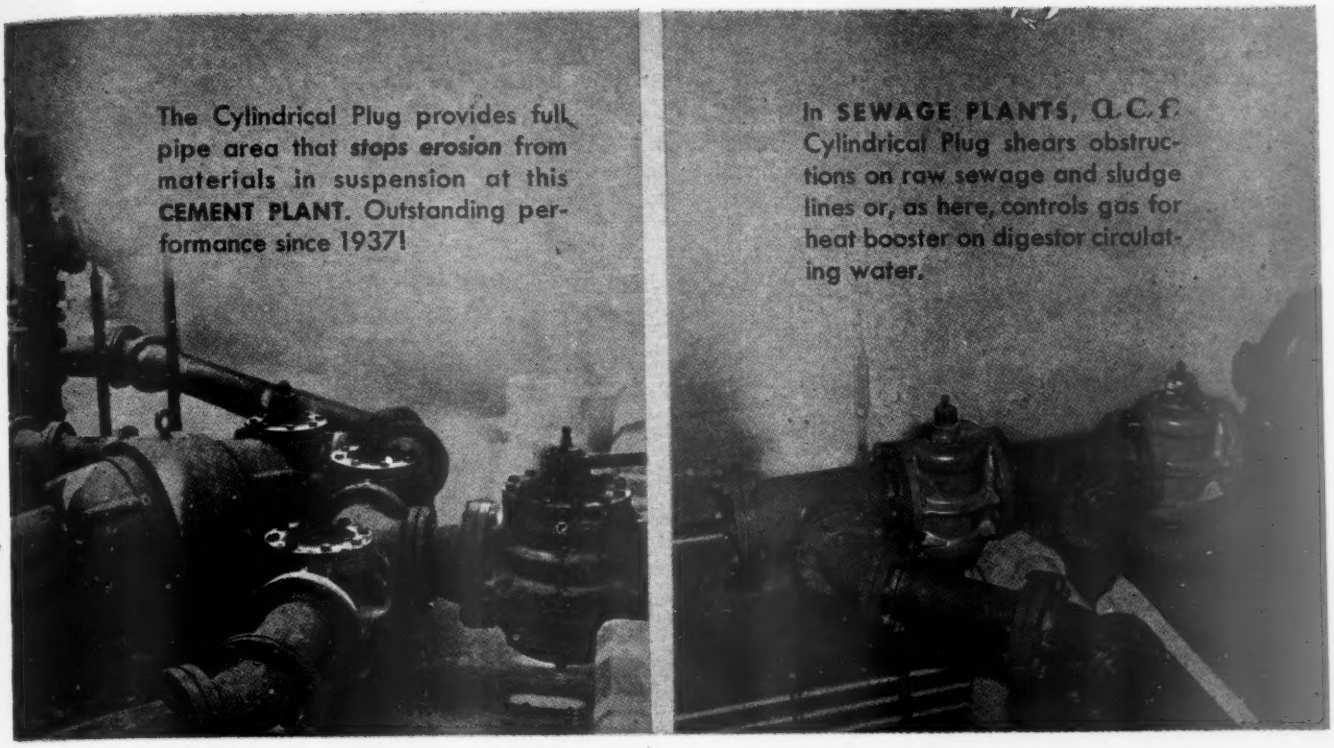
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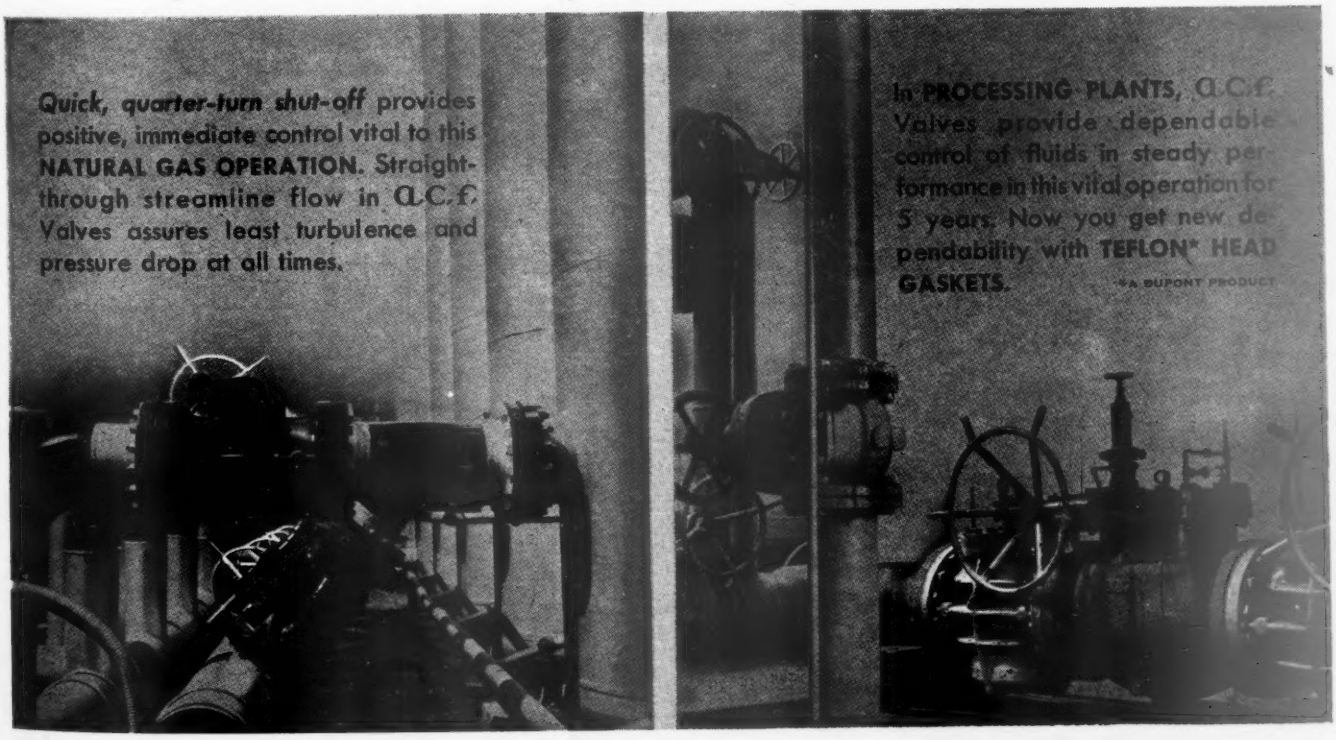
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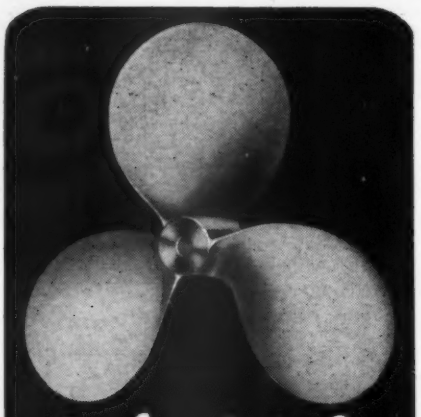

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Old "Huff and Puff" Finally Gives Up After Producing 427,221 bbl of Oil

Lloyd No. 6, the oldest producing well in the Ventura Avenue field, California, has finally been abandoned after a productive life of nearly 31 years. Born a trouble maker, old "Huff and Puff," as she was affectionately referred to by the many pumpers and service crews who knew her well, finally settled down to a useful existence and, during her lifetime, produced a total of 427,221 bbl of oil and 3,073,044,000 cu ft of gas.

The well, on the bluffs just east of Ventura Avenue, was the first well to be completed after the historic Lloyd No. 5 came in at the rate of 5000 bbl of oil per day and focused the attention of the entire petroleum industry in Ventura.

Spudded with company tools by Tide Water Associated Oil Company on December 4, 1922, a 25-in. hole was first drilled to 597 ft and 18⅝-in., 70 lb casing was set and cemented with 700 sacks of cement. A 17-in. hole was then drilled to 2844 ft, at which point it was reduced to a 15 in. hole, and taken down to 3166 ft, to which depth 11¾ in., 54 lb casing was set with 400 sacks of cement. An 11-in. hole was then drilled to 3660 ft and 8⅝-in. casing was set, the bottom 1060 ft of which was 36 lb and the balance 32 lb. This was cemented with 200 sacks of cement. A 7¾-in. hole was bottomed at 4434 ft and the well then set with a 6⅝-in., 26 lb liner, perforated from 3669-4434 ft with 100 mesh Smith slots. The perforated 6⅝ in. was run in on drill pipe and then blank 6⅝ in. was run in and screwed on the liner with a die nipple.

On August 6, 1923, eight months after spudding, old "Huff and Puff" was finally completed flowing after circulating thin mud for 8 hours. The initial rate was 780 bbl per day, gross and 702 bbl net, cut 10 per cent through a ⅞-in. bean, with 500 lb flow pressure. Gas production was estimated at 3,000,000 cu ft per day.

Up to March 1925 the well had produced a total of 193,383 bbl of oil and 418,944,000 cu ft of gas. This production was secured from the A-2 and C-2 zones. At that time the well was redrilled and deepened to 4854 ft. A 4¾-in. liner was set with 697 ft of 120 mesh Smith slotted perforations. This job was completed on June 21, 1925 and the well flowed all gas at approximately a 30,000,000 cu ft rate. Oil showed after 10 hours and the next day the well flowed 890 bbl gross; 862 bbl net, cutting 12.4 per cent and 9,900,000 cu ft of gas from C-2 and C-3 zones at a flow pressure of 300 lb.

Lloyd No. 6 flowed until January 1937 at which time it was placed on the pump. Production continued until recently when it declined to a point where it was no longer economical to produce.

In abandoning the well it was decided to salvage as much of the casing as possible. The following casing was recovered.

4¾ in. from 3755 ft
6⅝ in. from 1805 ft
8⅝ in. from 1789 ft
11¾ in. from 506 ft

A newly developed hydraulic casing tong was employed in the recovery of this casing and the job was complete in record time. No actual tests have been made on this casing but from visual inspection it appeared to be in good condition, including threads.

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PERSONALS

A. W. Scott, president of Wolf's Head Oil Refining Company, has been reelected president of the National Petroleum Association. Other reelected officers are: First vice president, **Fred G. Bannerot, Jr.,** of Elk Refining Company; second vice president, **Paul R. Beck,** Pennsylvania Refining Company; recording secretary, **E. M. Lyons,** Philadelphia, Pennsylvania; treasurer, **G. B. Hunter,** Quaker State Oil Refining Corporation, and general counsel, **Fayette B. Dow,** Washington, D. C.

William R. Pierce has been appointed commerce counsel of the National Petroleum Association. He replaces **Gerald Phelps** who is retiring. Pierce, a graduate of the Law School of National University, was assistant chief counsel in the Office of Price Stabilization. He was in charge of its transportation, public utilities, and fuels legal division. He has also served as an attorney in the Office of Price Administration. Phelps will continue in the general practice of law, particularly specializing in transportation and will be a consultant for the National Petroleum Association as his services are needed.

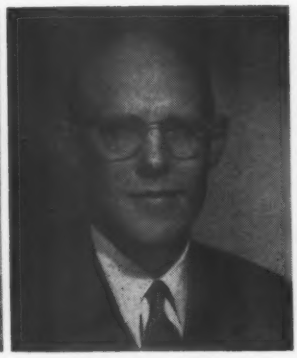
Edward N. Muller, assistant treasurer of Tide Water Associated Oil Company, retired last month after serving more than 33 years with the firm. Muller joined Tide Water in 1921 as credit manager of the Tide Water Oil Sales Corporation. Six months later he became assistant to the treasurer of the Tide Water Oil Company. He became regional treasurer, in charge of eastern division financial operations, in February 1940.

Captain Matthew T. Hannan has retired from Tide Water Associated Oil Company's eastern division fleet, after having sailed with the firm for 23 years. Hannan joined the company's marine department in June 1931 as an able-bodied seaman on the "S. S. Robert E. Hopkins." At the time of his retirement, Hannan commanded the "S. S. Frank Haskell."

James R. Branine has been appointed purchasing manager of Shell Oil Company's San Francisco operations, succeeding **William S. Floyd,** who has been loaned to the Office of Defense Mobilization. Branine was purchasing and stores representative for the New York area. He joined Shell in 1926 as a clerk.

John H. Crump has been elected to the board of directors of Commonwealth Gas Corporation. He has been associated with Commonwealth for the past nine years as its chief geologist and development engineer and has also been a vice president and director of Southwest Gas Producing Company, Inc., for the past three years.

J. E. Clark



J. H. Harmon, Jr.

M. E. Austin

J. E. Clark, production manager of Shell Oil Company's Denver exploration and production area, has been elected vice president in charge of the Midland, Texas area.

John H. Harmon, Jr., has been appointed general purchasing agent of The Pure Oil Company. He replaces **G. L. Parsons,** who has become purchasing agent emeritus.

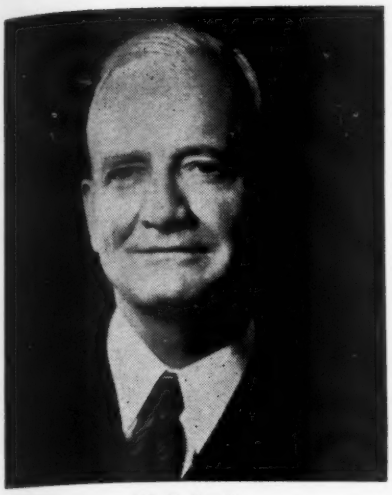
Harmon, a graduate of Princeton University, joined the company in 1934. He was made assistant general purchasing agent in 1947. Parsons' first Pure Oil job was as clerk in the producing division office in Charleston, West Virginia. He joined the company in 1916.

Merton E. (Doc) Austin has been promoted to division superintendent of the operating department for Sun Oil Company's Michigan production division. Austin has been division petroleum engineer at Mt. Pleasant. He succeeds the late **Clarence F. Knollenberg. George E. Haas** succeeds Austin as division petroleum engineer. **Harold E. Rudel** has been appointed division manager of the land department.

Austin, a graduate in petroleum engineering from Texas A and M College, joined Sun in June, 1940, as a roustabout at Odessa, Texas. He was made division petroleum engineer in 1950. Haas joined Sun in September of 1947 as a roustabout at Newaygo, Michigan, shortly after receiving his bachelor of science degree from the University of Pittsburgh. He Became assistant division petroleum engineer in June of 1954.

Vincent L. Verdiani has been appointed acting manager of the foreign department. He succeeds **William C. Taylor,** who is retiring because of ill health. Verdiani was employed by Sun as industrial products representative at Syracuse, New York in 1947. Prior to joining Sun, he was with the Syracuse Merchants National Bank and Trust Company (1934-42), and the air conditioning and construction firm of J. Cashier Company (1945-47).

Winner of Canada's fourth Annual Oilmen's Golf Tournament held at Banff Springs, Banff Hotel, Alberta, was John Poyen of Imperial Oil Limited. Betty Poyen congratulates her husband as Bobby Manahan, runer up, of Merrill Petroleums Ltd., stands by. Poyens won over Manahan in a match that had to go two extra holes. Poyen has now won the Royal Bank of Canada trophy for two straight years. George Dunlap, chairman of the tournament, presents prizes to E. T. Hall, Oil Development Company, Fosterton flight consolation runner up; Lee Lobdell, Lane-Wells Canadian Company, Fosterton flight winner, and S. P. King, Canadian Southern Oil Ltd., Fosterton flight consolation winner.



W. E. Pratt

Wallace E. Pratt has been named as the 1954 recipient of the American Petroleum Institute's "Gold Medal for Distinguished Achievement." Pratt, a graduate of the University of Kansas, is a former vice president of Standard Oil of New Jersey. He began his oil career in the Philippines working for the island government.

Richard L. Saunders, vice president and director of The Texas Company, has retired after 45 years with the company. Saunders joined Texaco in 1909 as a voucher clerk in the New York offices. He was elected a vice president in April, 1944, and a director in February, 1946.

James W. Foley and **A. Neil Lilley,** vice presidents of The Texas Company, have been elected directors of the company. Foley, a graduate of Texas A and M College, joined the compnay in 1932. He was elected a vice president in 1953. Lilley, vice president in charge of foreign operations department — eastern hemisphere, joined The Texas Company in 1933. He was elected a vice president in 1951.

P. E. Cochran, assistant manager (sales), has been appointed assistant manager of The Texas Company's 15-state central sales territory with headquarters in Chicago, Illinois. He succeeds **James M. Doss,** who recently was named territorial manager. Cochran has been associated with The Texas Company and affiliated companies since 1920, when he was hired as a helper in the barrel house of the company's Lawrenceville refinery. **C. R. Frohlin,** who has been assistant manager of the Norfolk division, has been promoted to assistant manager (sales), central territory, Chicago, succeeding Cochran. Frohlin has been with the company since 1930. **S. B. Miller,** who has been assistant manager (sales) of the Boston division, has been named assistant manager of Norfolk division, succeeding Frohlin. Miller has been employed by Texaco since 1935.

H. W. Lumb, assistant manager (sales promotion) in the Boston division, succeeds Miller. He has been with the company since 1925. **J. T. Bolger, Jr.,** who has been state manager for Oklahoma, has been transferred to Boston and succeeds Lumb. Bolger joined the company in 1936. **T. E. Cottrell,** previously zone manager in New Haven, Connecticut has been appointed state manager for Arkansas. He has been with the company since 1946. **R. L. Crenshaw,** who has been a zone manager in Dallas, Texas, has been promoted to state manager for Central Texas. His service with the company dates back to 1933.

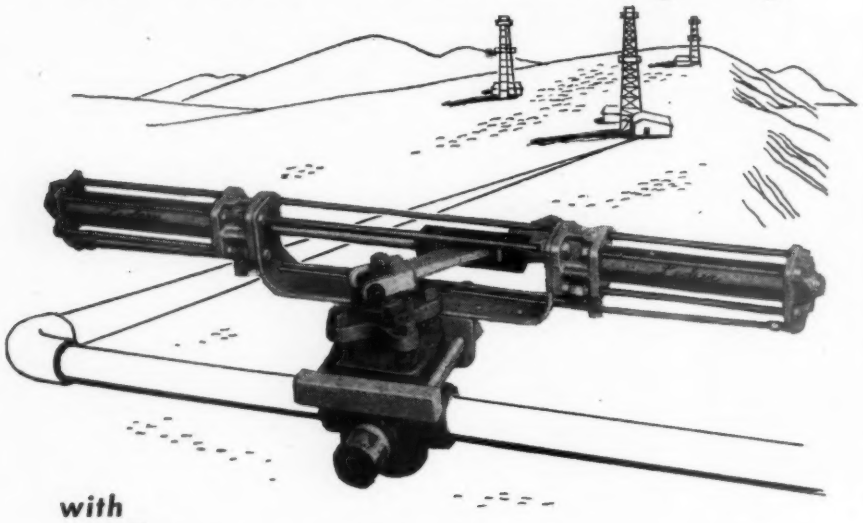
The New York Chapter of Nomads was host to a fall golf party at Hackensack Golf Club, Oradell, New Jersey, on September 28th. Ninety-one members and their guests participated in the tournament. Visitors at the tournament were: William Dabney, Mene Grande Oil Company, Venezuela; L. Hulin, Hayward Tyler and Company, England; Charlie Richards, Gray Tool Company, Houston, Texas, and Roy Fly, Mene Grande, Venezuela. Tournament winners were: George Eichler, The Petroleum Equipment Publishing Company (fewest putts — Nomad); John D. Evans, Lucey Export (low gross — Nomad); Joseph Chanda, A. O. Smith (fewest putts — Nomad), and A. B. Cashman, Keenen-Cashman Company (low net — guest).

Additional tournament winners were: Kenneth Shyvers, Arabian American Oil Company (nearest to pin — guest); W. E. Volkman, Cardwell Manufacturing (low net — Nomad); A. J. Laycock, Foster Wheeler (fewest putts — guest); H. T. Leonard, Midwest Pipe and Supply (low gross — guest); Alan T. Lockard, R. S. Stokvis and Sons (high gross — Nomad); N. M. Hotz, Asiatic Petroleum (high gross — guest), John Richbourg, Tube-Turns, Inc. (longest drive — guest), and Walter D. Wood, A. O. Smith Corporation (longest drive — Nomad). The President's Cup was won by T. N. Shults, Mid-Continent Supply Company.

Personals

Petroleum Electric Power Association's president James E. Moody, Southwestern Gas and Electric Company, congratulates W. L. Pearson, Southwestern Public Service Company, the association's president-elect for the coming year. F. R. Woerner, Texas Electric Service Company, was elected secretary-treasurer, and Fred B. Clark, Arkansas Power and Light Company, was elected vice president.

AUTOMATIC CONTROL of Flow and Gauging



with

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The Ledeen Tandem Type Actuator, illustrated above, is a pneumatically or hydraulically operated unit for direct or remote control of standard plug valves. It is a package unit and is mounted directly on the valve without need of any special manifolds or outside supports.

★ Direct or Remote Control.
★ Automatic Processing.
★ Safety Installations.
★ Multiple Central Control.
★ Ledeen Valve Actuators are available for operation of Gate, Diaphragm, Plug and other Flow Control Valves.

This tandem actuator, with two cylinders working as a unit, delivers positive, smooth and balanced torque to the valve stem. The balanced design eliminates any cantilever load on the body or eccentric load on the stem.

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VALVE ACTUATORS
AIR HYDRAULIC PUMPS & BOOSTERS

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▸ **Homer Z. Martin,** assistant director of the development division, Esso Laboratories, Standard Oil Development Company, is being transferred to the research division as assistant director for one year on a rotational assignment. **Arnold F. Kaulakis** and **Henry J. Ogorzaly** will assume Martin's responsibilities in the development division.

Martin, a graduate of the Armour Institute of Technology and the University of Michigan, joined the company in 1937. Kaulakis began his professional career in the petroleum refining industry in Texas after receiving his bachelors degree in chemical engineering from M.I.T. He joined the company in 1942. Ogorzaly is a graduate of M.I.T. also. He joined the Baton Rouge laboratories of Esso Standard Oil Company in 1937. Ogorzaly was transferred to the Development Company in 1942.

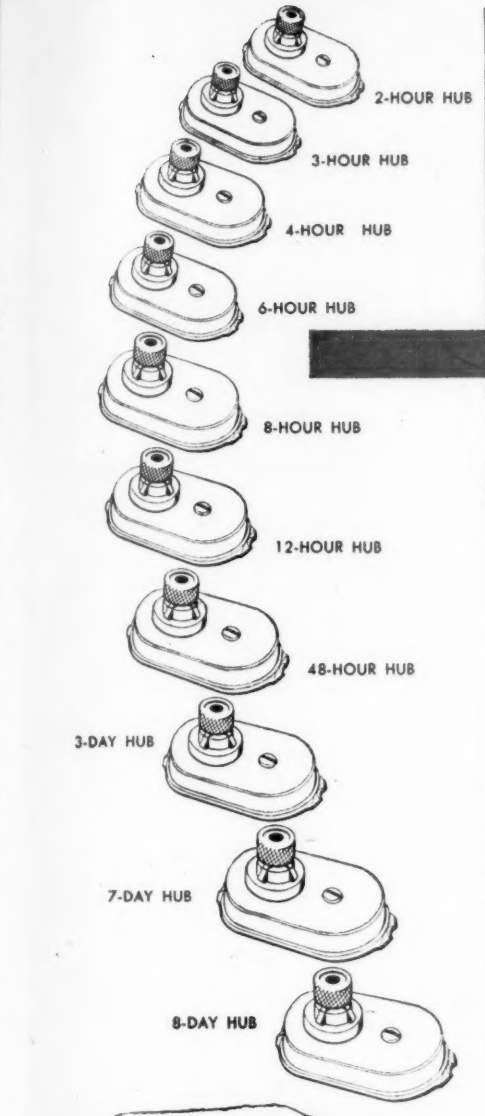
▸ **H. N. Mallon,** president, Dresser Industries, Inc., has been elected a director of the American Gas Association. Other officers elected included: **F. M. Banks,** president of Southern California Gas Company, president; **Dean H. Mitchell,** president of Northern Indiana Public Service Company, first vice president; **C. H. Zachry,** president of Southern Union Gas Company, second vice president, and **Vincent T. Miles,** treasurer of Long Island Lighting Company, treasurer.

E. Russell Griffith has joined the AGA as research engineer. He will assist T. L. Robey, coordinator of research for AGA under the gas industry's coordinated promotion, advertising, and research plan. Griffith will be employed primarily on pipe line research work.

▸ **A. R. Rehrig** and **W. M. McEldowney** have been appointed to the Department of Interior's oil and gas division staff. McEldowney will work on transportation and storage problems and Rehrig will serve as a refining technologist. McEldowney was formerly with Gulf Oil Corporation.

Roscoe A. Catell has been named chief of the newly created petroleum and natural gas division of the Burau of Mines. This work was formerly under a branch of the fuel and eplosives division.

▸ **Richard G. Gettell,** the Texas Company, has been appointed as a consultant to J. Ed Warren who is heading the oil and gas aspects of a task force study. Other appointees were: **Richard J. Gonzales,** Humble Oil and Refining Company; **Minor Jameson,** IPAA; **Serge B. Jurenev,** Continental Oil Company, and **C. Pratt Rather,** Southern Natural Gas Company.



The Turret On Top Does The Trick

Illustrating how the speed changing turrets are applied to the chart arbor to provide a wide selection of rotation rates.

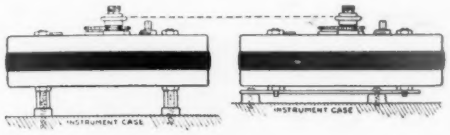
Is Your Chart Drive Inventory Ready for Cold Weather?

JUST STOCK BASIC ROCKWELL CHART DRIVES plus a selection of inexpensive SPEED CHANGING TURRETS

FOR REPLACEMENT SERVICE, the Rockwell chart drive is the most versatile, economical you can use. Design dimensions were deliberately established so that the drive can be adapted to fit practically all instruments. One adaptor is furnished with each drive. There is no problem with rotation rates either. Speed changing turrets lock onto the chart arbor of the Rockwell drive to provide any one of 11 rotation cycles. Think what these features mean to you in reduced chart drive inventory, servicing and all-around flexibility of application.

Get facts now on versatile, long-lived Rockwell chart drives. Learn how their use in your instrument shop will save time and money. Write for bulletin 1079.

ADAPTORS TO FIT PRACTICALLY ANY INSTRUMENT



Illustrations show how adaptors are used to correctly locate Rockwell chart drives within instrument cases both as to position and height.

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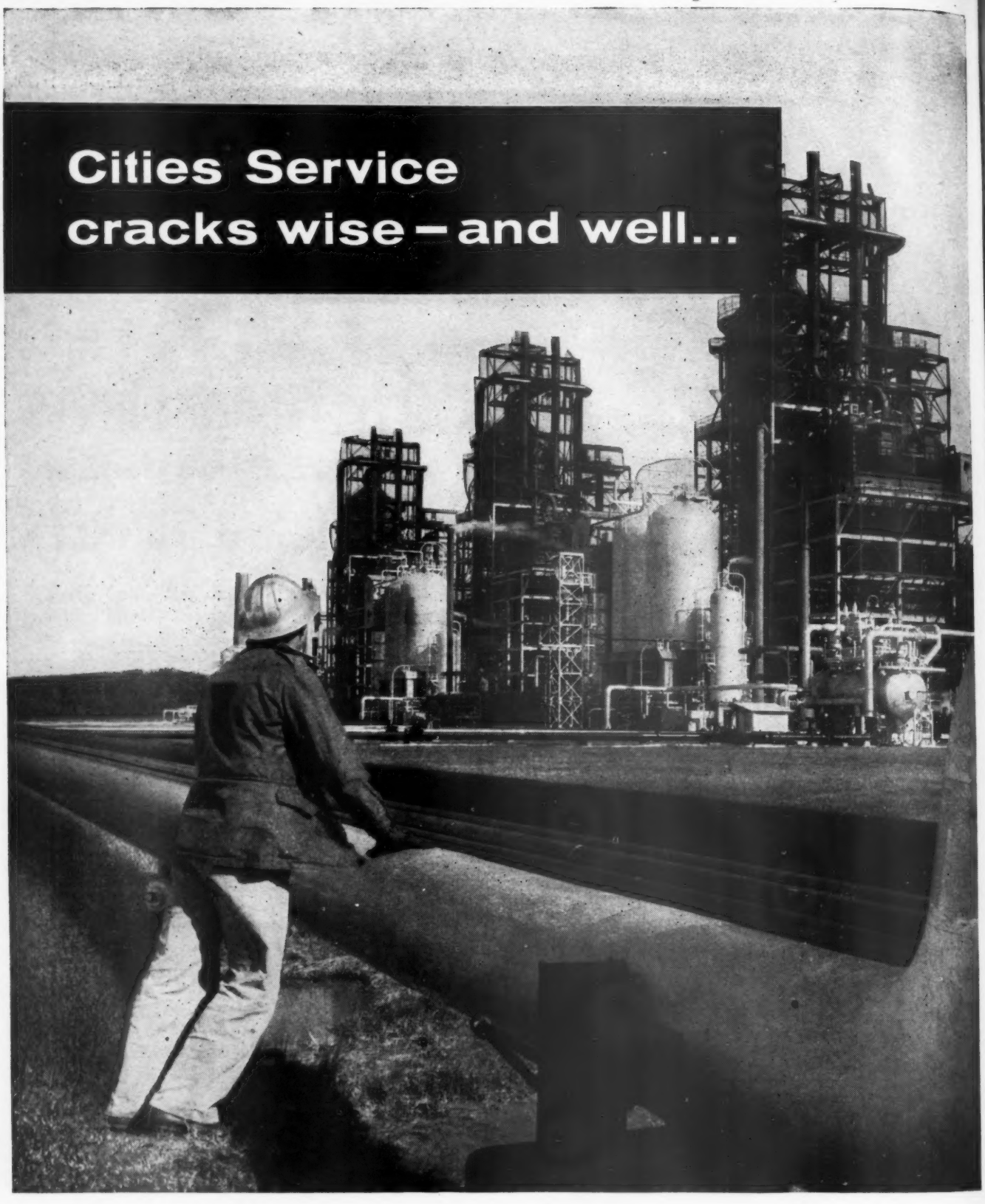
Cities Service cracks wise—and well...



These three catalytic crackers dominate the skyline of our Lake Charles, Louisiana, refinery which normally processes 175,000 barrels of oil every day.

CITIES SERVICE

A Growth Company

Personals

William F. Styler, Jr., has been named controller of Deep Rock Oil Corporation. He succeeds Allyn R. Bell, Jr., who has resigned to become controller of General Crude Oil Company. Styler, a Deep Rocker since 1949, has served for the past three years as assistant to the president. He will continue in this capacity, along with his new duties as controller. Styler came to Deep Rock 5 years ago as manager of the company's tax department. He is a graduate of the University of Arkansas.

Paul D. Williams has been appointed acting secretary-treasurer for the Western Petroleum Refiners Association. Williams, who has served as technical director the past 10 years, succeeds **John C. Day.** Before joining the staff of WPRA, Williams was associated with the Globe Oil and Refining Company, the old Omar Refining Company and the Lairo Oil and Gas Company.

Fred Powell has been named to head the manufacturing department of Standard Oil Company of California succeeding **O. N. Miller. J. E. Gosline** takes over the producing department, which previously operated directly under vice president **J. E. Toussaint.**

Powell was formerly president of California Research and Development Corporation, a Standard subsidiary. He has been serving as assistant manager of manufacturing with supervision over chemical production. He is a graduate of the University of Washington and joined Standard in 1925. Gosline, former assistant general manager of producing, has been with Standard since 1933. He is an alumnus of the University of California.

M. A. Wright, executive vice president and a director of The Carter Oil Company, has been appointed coordinator of all producing activities of Standard Oil Company (New Jersey). He succeeds the late **Roger H. Sherman** as head of the producing coordination department. A graduate of Oklahoma A and M College, Wright joined Carter, a Jersey Standard affiliate, in 1933 as a roustabout. He became Carter's chief petroleum engineer in 1943 and assistant manager of the production department the following year. He was elected to his present position in 1952.

Richard N. Meinert, associate chief of research for The Carter Oil Company, has been appointed associate coordinator of production research in the producing department of Standard Oil Company (New Jersey). A graduate of Franklin and Marshall College, Meinert received his doctorate from Northwestern University in 1930. He joined Standard Oil Development Company as a chemist in 1936 after serving 6 years as an instructor at Brown University. In 1947 he became assistant chief of research at Carter.

Nelson Y. Ruth, a director of The Carter Oil Company has been named an assistant coordinator of Jersey's producing department. Ruth has been with Carter 27 years. He joined the company in 1927 shortly after receiving a degree in civil engineering from Oklahoma A and M College. He was elected to the Carter Board of directors in 1953.

Herbert R. Straight was honored recently on his 80th birthday at a recognition dinner given by officers and directors of the Cities Service Oil Company. As senior oilman in the Mid-Continent, Straight has been affectionately called the "Dean of Mid-Continent Petroleocrats."

TRANS-PENN OIL COMPANY reports

LATTICE BRAID* Teflon†

PUMP PACKING is *not* affected

by waxes, or steam used in cleaning

*Registered Trademark. *Only* Garlock makes LATTICE BRAID rod and shaft packings.

On pumps handling blending waxes at 170° to 200°F., Trans-Penn Oil Company of Titusville, Pa., has found that LATTICE BRAID Teflon packing lasts 8 to 10 times longer than other packings. The reason, according to A. W. Carlson, Superintendent at Trans-Penn, is that Garlock's LATTICE BRAID Teflon Packing is *unaffected* by either the hot blending waxes or the steam used in cleaning the pumps.

Put Garlock LATTICE BRAID Packing to work for your company. All the braided strands of this unique packing are lattice linked together into one structural unit. The strands hold together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

LATTICE BRAID is made from flax, cotton, asbestos, wire-inserted asbestos, Teflon, and asbestos with Teflon impregnation—for various types of services.

Get all the facts about LATTICE BRAID *Packings. Contact your Garlock representative or write for new folder AD-131.*

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† The Du Pont Company's Trademark

GARLOCK LATTICE BRAID PACKING

XUM

DEATHS

Harper C. Patton, vice president of J. D. Streett and Company, Inc., and president of Streett Towing Company, died October 6. He had been with the company since 1927 and associated with the oil business since 1916. Patton was a member of the 25 Year Club and numerous other trade groups.

Joseph C. Stiedle, retired vice president and treasurer of Standard of Kentucky, died July 21, 1954, in Louisville, Kentucky. Stiedle began his career as an office boy.

Walter M. Cross, Jr., president of Cross Laboratories, Inc., Kansas City, died July 25, 1954, in Kansas City.

P. J. Ryan, store manager and field representative for the Bethlehem Supply Company at Graham, Texas, died on September 18, 1954, at his home in Graham, Texas. "Pat" Ryan had been employed by Bethlehem since October, 1936, and had been the store manager at Graham for the past 11 years.

Virgil O. Wood, geologist and bank official died in Oklahoma City, Oklahoma, August 26, 1954. Wood was a partner in the Broswood Oil Company and vice president and director of the Citizens State Bank. He was a graduate of Oklahoma University.

Jorge L. Cumming, head of exploration for Pemex, died October 13, 1954, in Acapulco, Mexico. He had been in charge of all exploration activity for Pemex since 1953.

Maximilian H. Leister, retired general manager of Sun Oil Company's motor products department, died September 19, 1954. Leister began his business career with the Katz Advertising Agency and later engaged in advertising and promotion work with the Saturday Evening Post and other national magazines. He joined Sun Oil Company as special assistant in the motor oil department in 1921. On April 1, 1924, he became manager of motor product sales in the Philadelphia district, and eight months later was appointed general manager of the motor oil divsion and advertising manager.

When Walter C. Pew, then general sales manager of the company, went into the Armed Service in 1942, Leister became acting general sales manager, serving in that capacity until 1946 when he became general manager of the motor products department. He was a graduate of the Pennsylvania Military College and the University of Pennsylvania.

R. K. "Bob" King, former manager of the Hunt Tool Company, Corpus Christi, Texas division, died September 5, 1954. King had been with Hunt for 18 years. He had recently moved to Casper, Wyoming to represent the Hunt Tool Company in the Rocky Mountain area.

Walter Dietmeyer, division service superintendent of North Shore Gas Company, died October 5, 1954. Dietmeyer had worked for North Shore for over 25 years.

Raymond Foss Bacon died October 14, 1954, at his home in Bronxville, New York. Bacon was the former director of the Mellon Institute for Industrial Research and an internationally known chemical engineer. He began his career as a chemist in the U. S. Bureau of Science in Manila in 1905. Bacon was a graduate of DePaw University. He received his M.S. and doctorate at the University of Chicago and a Doctor of Science degree from the University of Pittsburgh.

Gerald B. Rush, superintendent of production for Hancock Oil Company, died September 19, 1954. Rush was a prominent developer of Signal Hill field in California.

Wayne R. Harshbarger, superintendent of The Texas Company's operations in Coalinga, California, died September 20, 1954. Harshbarger had been with the Texas Company in Coalinga for 20 years.

William Yates Blair, production superintendent for Tide Water Associated, died recently in Ventura, California.

Harry Bess, one time president of Rainbow Petroleum Company, died recently in Long Beach, California. He had been active in the oil industry for 65 years. Bess was formerly associated with B and H Oil Company and Bush Voorhis Oil Company.

Forest Goody, Long Beach drilling contractor, died recently in Los Angeles, California.

Ellwood J. Munger, founder of the Munger Oil Information Service, died October 4, 1954. Munger established his oil field scouting service in 1919 while working with the Union Oil Company. His first publication covered the Los Angeles Basin. Later he increased his coverage to include the entire state and began publication of a daily report in 1929.

WISCONSIN-POWERED "MUD BAZOOKA"

Gives Mud Drilling a Lift!

Power TO FIT THE JOB

Power TO FIT THE MACHINE

"Mud Bazooka," manufactured by DELTA TANK CORP., Baton Rouge, La., working in West Webster Field, Harris County, Texas

The advanced rotary drilling technique of employing Barium Sulphate Mud (4.3 times heavier than water), or other specified muds for carrying bottom hole drill cuttings to the surface and preventing blowouts, has brought about a demand for a new type of equipment . . . the "MUD BAZOOKA", shown here.

Mud material is hauled to the drilling rig in bulk trucks, dumped into the "Bazooka" hopper and a screw conveyor, operated by a 2-cylinder Wisconsin Air-Cooled Engine, elevates it to the storage bin. The base of the bin has an air operated valve manifold that accurately controls the discharge to any pre-determined mixture.

Tremendous time- and manpower savings are reported through the use of this new "Mud Bazooka" which takes the place of "manhandling" weight material (the bin in the picture has a 600-sack capacity). For this important service a Model TFD 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine provides dependable, steady-going "Lugging Power" that keeps the job moving.

Whether conveying mud materials, pumping oil or operating many other types of oil field utility equipment, you can't do better than to specify "Wisconsin Engine Power".

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MILWAUKEE 46, WISCONSIN
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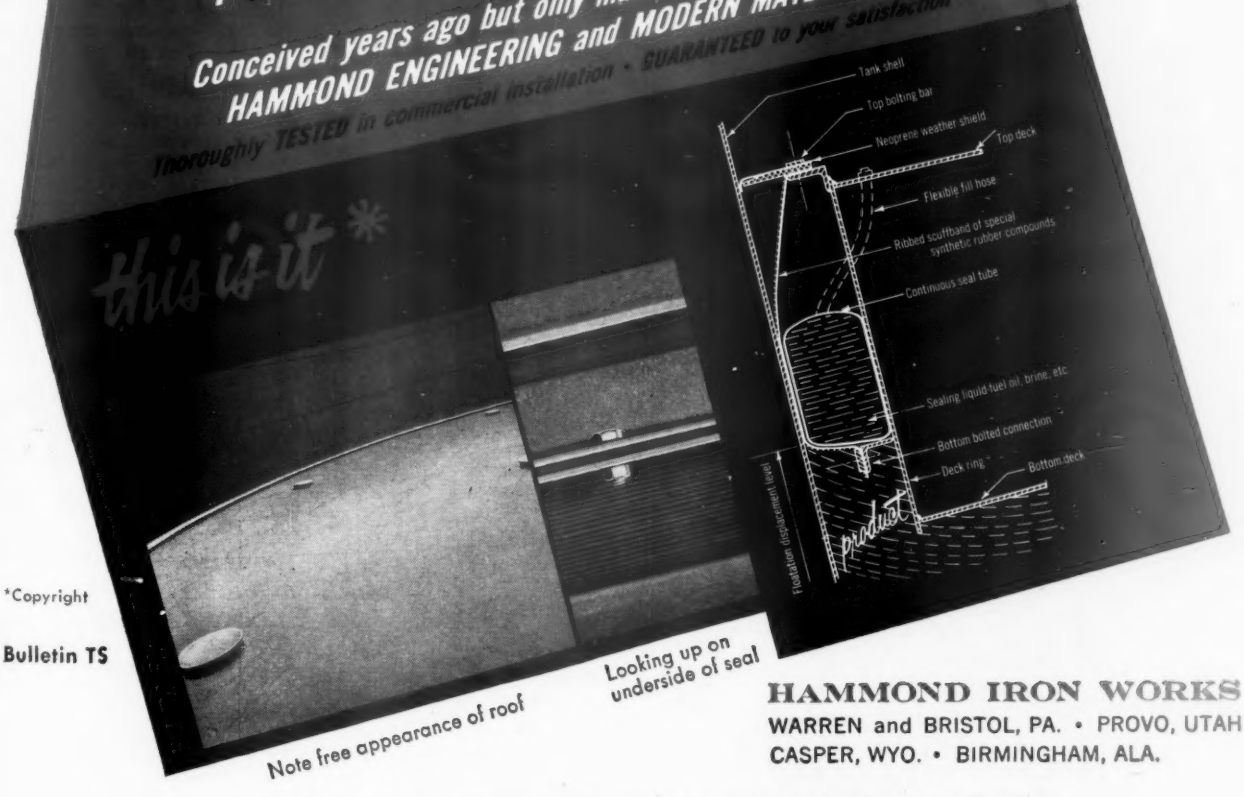
Conceived years ago but only made possible by combining HAMMOND ENGINEERING and MODERN MATERIALS

Thoroughly TESTED in commercial installation • GUARANTEED to your satisfaction



Note free appearance of roof

Looking up on underside of seal

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LAUGH with BARNEY

One oil man to another: "Hear you brought in a dry hole last week."

Second Oil Man: "Please. Let's just say I brought in a long, thin swimming pool."

" " "

"Is there anything you'd like to eat before your execution?" asked the warden.

"Mushrooms," replied the condemned man. "I've always been afraid to try them."

" " "

"Got a sweetheart yet, Lily?"

"Sure, an' he's a regular gent."

"Zat so?"

"Yep. He took me to a restaurant night 'fore last and poured his coffee into a saucer to cool; but, he didn't blow it like common people does—he fanned it wid his hat!"

" " "

A newspaper got a call from a man's wife who wanted her spouse's name put in the obituary column because she caught him kissing his secretary.

"How long has he been dead?" she was asked.

"He starts tomorrow."

" " "

A man was perched atop a building in a large southern city and it looked like an attempted suicide. A policeman made his way to the roof to persuade him not to jump. "Think of your maw and family," pleaded the cop.

"Ain't got any."

"Well, think of your girl friend."

"I hate women!"

"All right," said the cop desperately. "Think of Robert E. Lee."

"Who's he?"

"Jump, you derned Yankee!"

An optimist and pessimist had recently gone into partnership and were reviewing their first month's business. "Well, we had a wonderful month," the optimist said. "Trade has flourished. We've had a continual run of customers."

"Yep," agreed the pessimist sourly. "We had some pretty good business, but just look at those doors. If people keep shoving through them, the hinges will be worn out in another month."

" " "

The absent-minded professor was fumbling for his railway ticket and, as usual, couldn't find it. The conductor finally said: "Oh, that's all right, sir, I'll just pick it up later when I come through again."

"That will be fine," replied the professor, "but that won't help me. You see, I've just got to find it for another reason. I've got to know the name of the town I'm getting off at!"

" " "

A Marine sergeant caught a recruit with a single button unfastened. "Oh," he sneered, "sunbathing, eh?"

" " "

Once upon a time three hermits lived in a cave and spent all day staring at the wall, never speaking. One day a horse ran past the cave entrance. Six months later, one hermit mumbled, "That was a fine brown horse."

Two years after that another hermit said, "That wasn't a brown horse; it was white."

About a year later, the third hermit got up and stalked toward the entrance, exclaiming, "If there's going to be this constant bickering, I'm leaving."

Walking into the post office, a man listened to two girls talking behind the counter. "She wore a divine cloak; it was a redingote design in gorgeous brocade, trimmed with fox fur and had wide pagoda sleeves. It must have cost $50 if it cost a nickel."

At this point the impatient gentleman interrupted, "Excuse me, I wonder if you could provide me with a dinky little stamp with perforated hem, treated on the reverse side with a light coating of gum arabic? Something for about two cents?"

" " "

Pity the poor clergyman who bought a used car and then didn't have the vocabulary to run it.

" " "

Inviting a friend to his wedding anniversary, an Irishman explained: "We're on the 7th floor, Apt. D. Just touch the button with your elbow."

"And why should I use my elbow?"

"Well, for heavens sake!" said the exasperated Irishman. "You're not coming empty-handed, are you?"

" " "

A Texas posse had captured a horse thief and was about to administer some typical local justice to the miscreant by hanging him from the nearest cottonwood. Just as they were ready to tighten the rope, an itinerant minister rode by and expressed a wish to offer a prayer for the condemned man. "Oh, no!" howled one member of the necktie party. "This ain't no fit time and place." "Why not?" asked the preacher. "Here is a man about to pass into eternity and he should be comforted and his soul saved if possible." . . . **"SAVED!"** bellowed the objector. "You want to ask to get this varmint into Heaven when we're hangin' him because he ain't even fit to live in Texas!"

" " "

"It scares me to death every time I hear one of those musical auto horns."

"Why is that?"

"The fellow who stole my wife had one on his car. Now every time I hear one of those horns, I'm afraid he's bringing her back."

" " "

Indians captured a wagon train and one of the young women asked the chief.

"Listen, big boy, you're not holding me for ransom, are you?"

"Not me!" replied the chief. "Let Ransom get his own women."

" " "

"Johnny, what is a comet?"

Johnny looked blank.

"What is a star with a tail?" the teacher prompted.

"Mickey Mouse!"

" " "

The two colored gentlemen were having an argument about ghosts. One of them claimed to have seen a ghost the night before.

"What was dis here ghos' doin' when you las' seen him?" asked the doubting one.

"Jes' fallin' behin,' Mistah, fallin' behin' rapid."

" " "

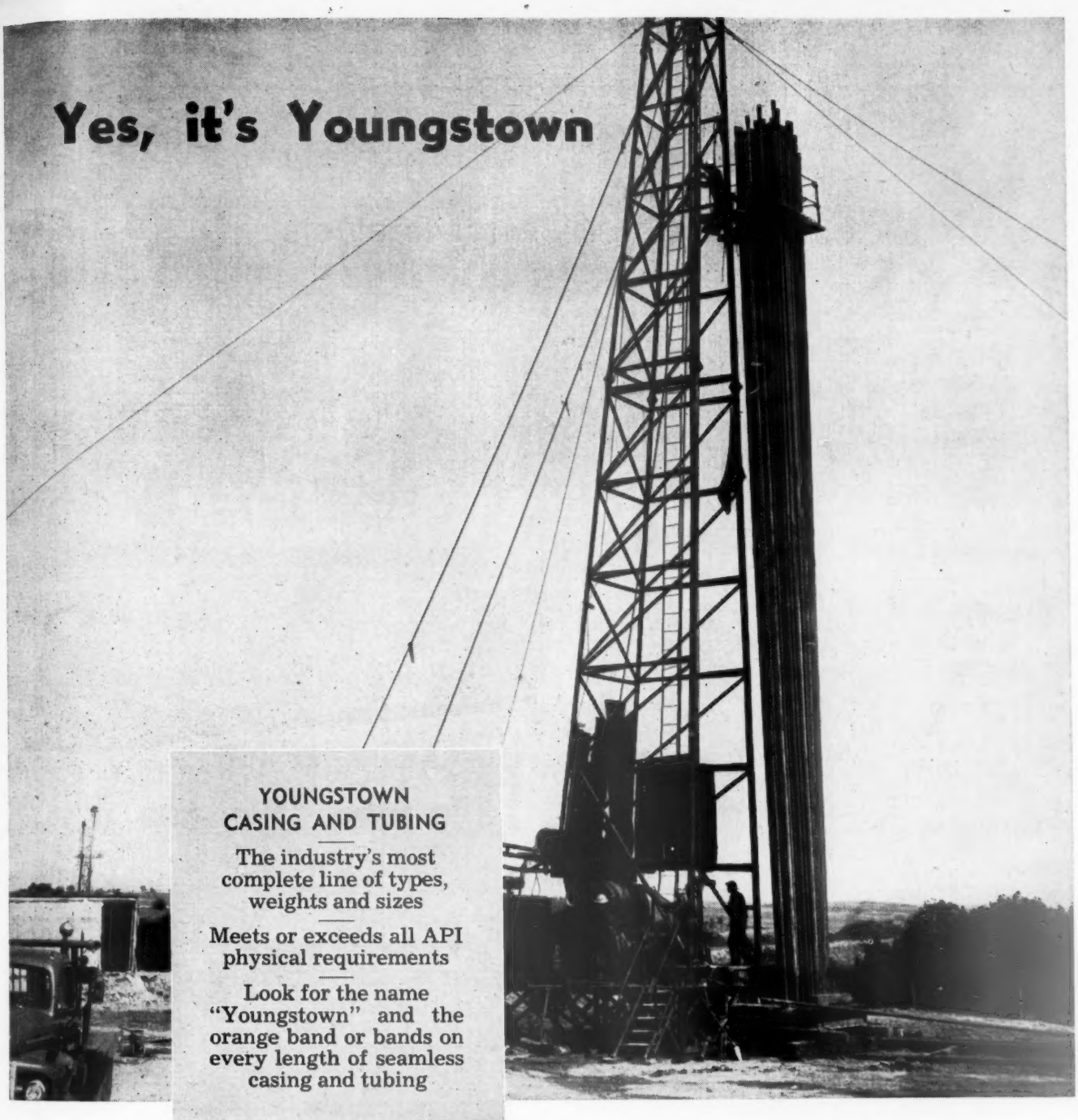
Clerk: This medicine is powerful . . . the best stuff we've ever had for the liver."

Customer: Can you give me any specific reference—someone who has taken it with good results?

Clerk: There was an old man down the street who took it for his liver for three years.

Customer: Did it help him?

Clerk: He died last week, but they had to beat his liver with a stick for three days after he died before they could kill it.



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Meets or exceeds all API physical requirements

Look for the name "Youngstown" and the orange band or bands on every length of seamless casing and tubing

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In thousands of wells from the Gulf to Canada—many on the pump for twenty years and more—Youngstown Tubing is serving dependably. So when you run a string in any well, shallow or deep, you can be sure of performance with Youngstown Seamless Tubing.

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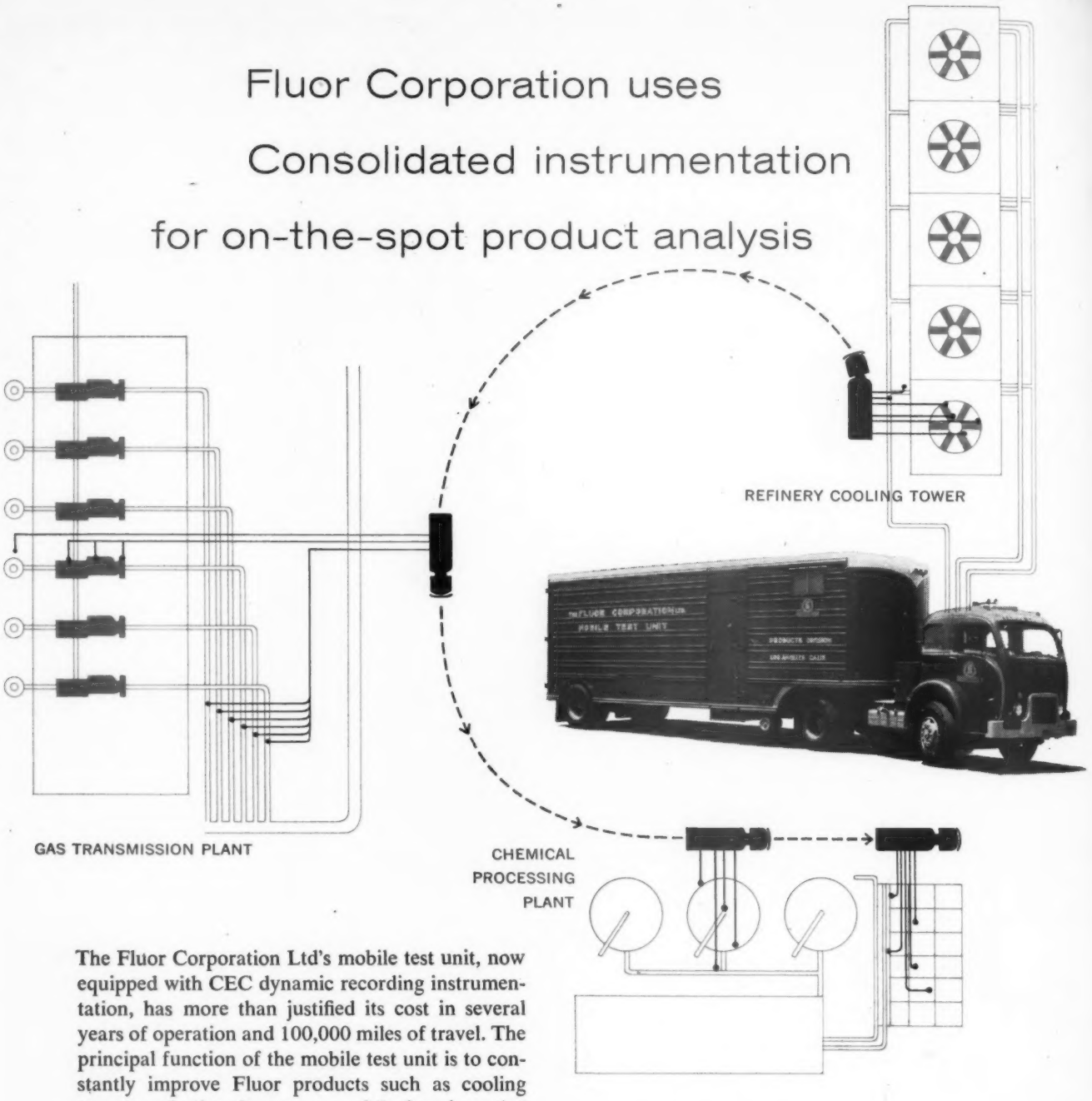
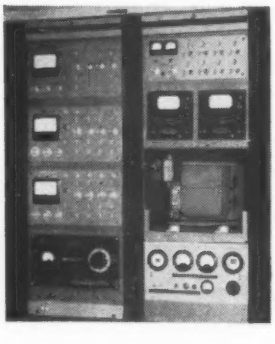
Fluor Corporation uses Consolidated instrumentation for on-the-spot product analysis



The Fluor Corporation Ltd's mobile test unit, now equipped with CEC dynamic recording instrumentation, has more than justified its cost in several years of operation and 100,000 miles of travel. The principal function of the mobile test unit is to constantly improve Fluor products such as cooling towers, pulsation dampeners and fin fan air-cooled heat exchangers by on-the-spot dynamic testing under actual operating conditions. Using a 14-channel Consolidated Recording Oscillograph, Carrier Amplifiers, Transducers and associated CEC equipment, the mobile unit can measure and permanently record every physical phenomenon encountered in the operation of Fluor's products for the petroleum and petro-chemical industries. The attractive mobile unit in its specially built van trailer serves other purposes aiding the solution of field engineering problems and conducting basic research.



Consolidated dynamic recording equipment: recording oscillograph, vibration meters, bridge balance and carrier amplifiers, are rack-and-panel mounted in Fluor's mobile research laboratory.

Free Catalog. *Write for illustrated brochure "Data Processing Instruments." Ask for Bulletin 1301-X5.*

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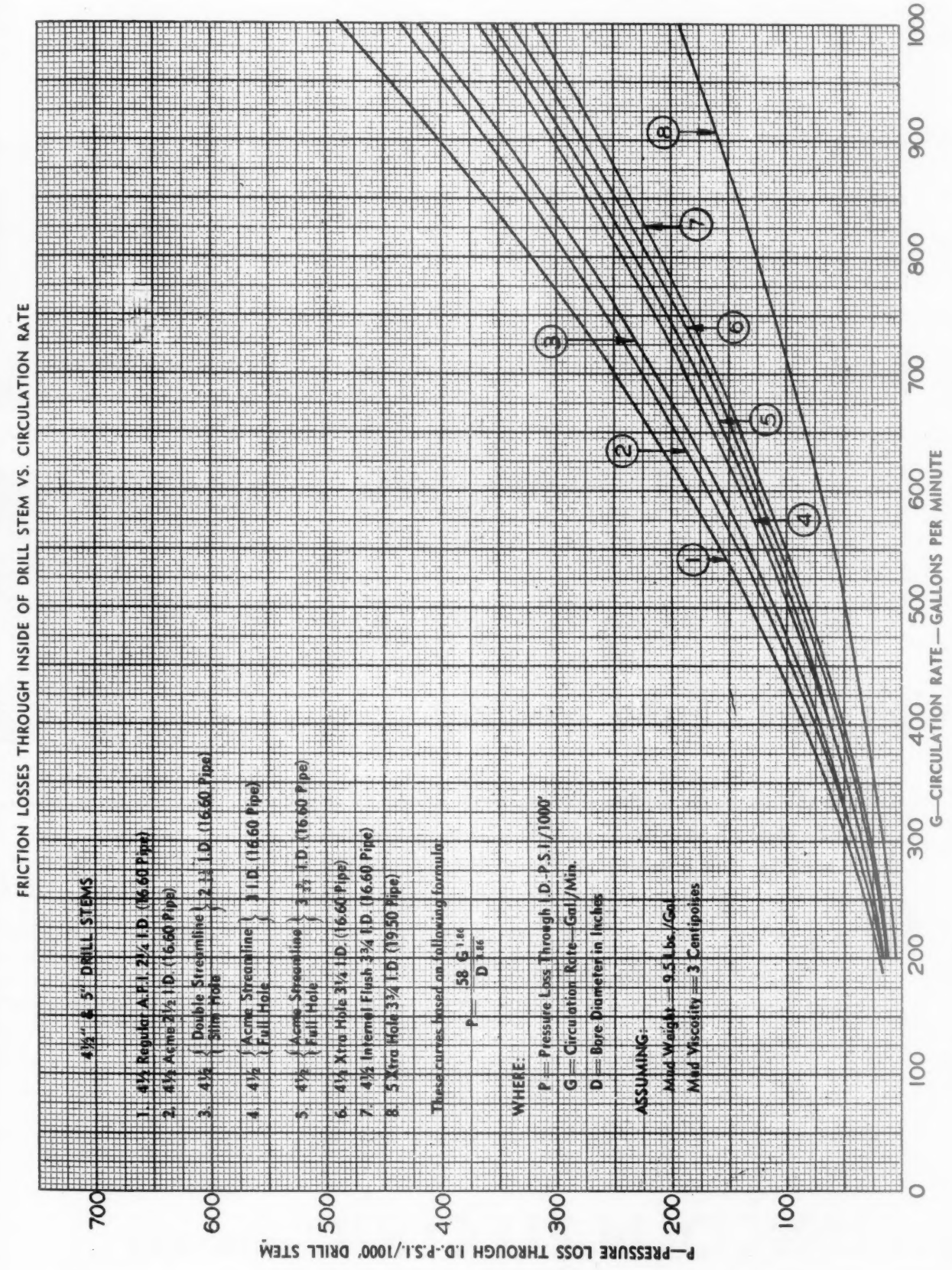
DRILLING HYDRAULICS


FRICTION LOSSES THROUGH INSIDE OF DRILL STEM VS. CIRCULATION RATE
4½" & 5" DRILL STEMS
1. 4½ Regular A.P.I. 2¼ I.D. (16.60 Pipe)
2. 4½ Acme 2½ I.D. (16.60 Pipe)
3. 4½ { Double Streamline } 2 13/16 I.D. (16.60 Pipe)
{ Slim Hole }
4. 4½ { Acme Streamline } 3 I.D. (16.60 Pipe)
{ Full Hole }
5. 4½ { Acme Streamline } 3 3/16 I.D. (16.60 Pipe)
{ Full Hole }
6. 4½ Xtra Hole 3¼ I.D. (16.60 Pipe)
7. 4½ Internal Flush 3¾ I.D. (16.60 Pipe)
8. 5 Xtra Hole 3¾ I.D. (19.50 Pipe)
These curves based on following formula:
P = 58 G^1.86 / D^4.86
WHERE:
P = Pressure Loss Through I.D.-P.S.I./1000'
G = Circulation Rate—Gal./Min.
D = Bore Diameter in Inches
ASSUMING:
Mud Weight = 9.5 Lbs./Gal.
Mud Viscosity = 3 Centipoises
P—PRESSURE LOSS THROUGH I.D.-P.S.I./1000' DRILL STEM
G—CIRCULATION RATE—GALLONS PER MINUTE
0
100
200
300
400
500
600
700
800
900
1000

Courtesy of Hughes Tool Company

"JETWELDING"

...greatest team for low cost, high speed hand welding

LOWEST *manual welding costs are achieved* with "Jetweld", the high speed welding electrode developed and introduced by Lincoln, and "Fleetwelder" — Lincoln's AC transformer-type welder.

For the first time, "Jetweld" utilizes powdered metal in the electrode coating... enabling use of higher currents to speed welding 35% and more. Iron powder becomes an additional source of metal for the weld. Welds are more uniform, free of undercut, of X-ray quality. Welds require a minimum of skill and effort on the part of the operator.

TYPICAL APPLICATIONS:

Figure 1. *Down-hand welding of flanges.*

Photo courtesy of National Tank Co., Tulsa, Okla.
Figure 2. *Welding of end flange to cylinder.*

CHECK LINCOLN'S NEW LOW PRICES

Lincoln's new combination of lower AC welder prices and faster welding with "Jetweld" can cut your welding costs. See for yourself. Have your Lincoln representative check your requirements for electrodes and welders. Call or write.

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Dept. 2808
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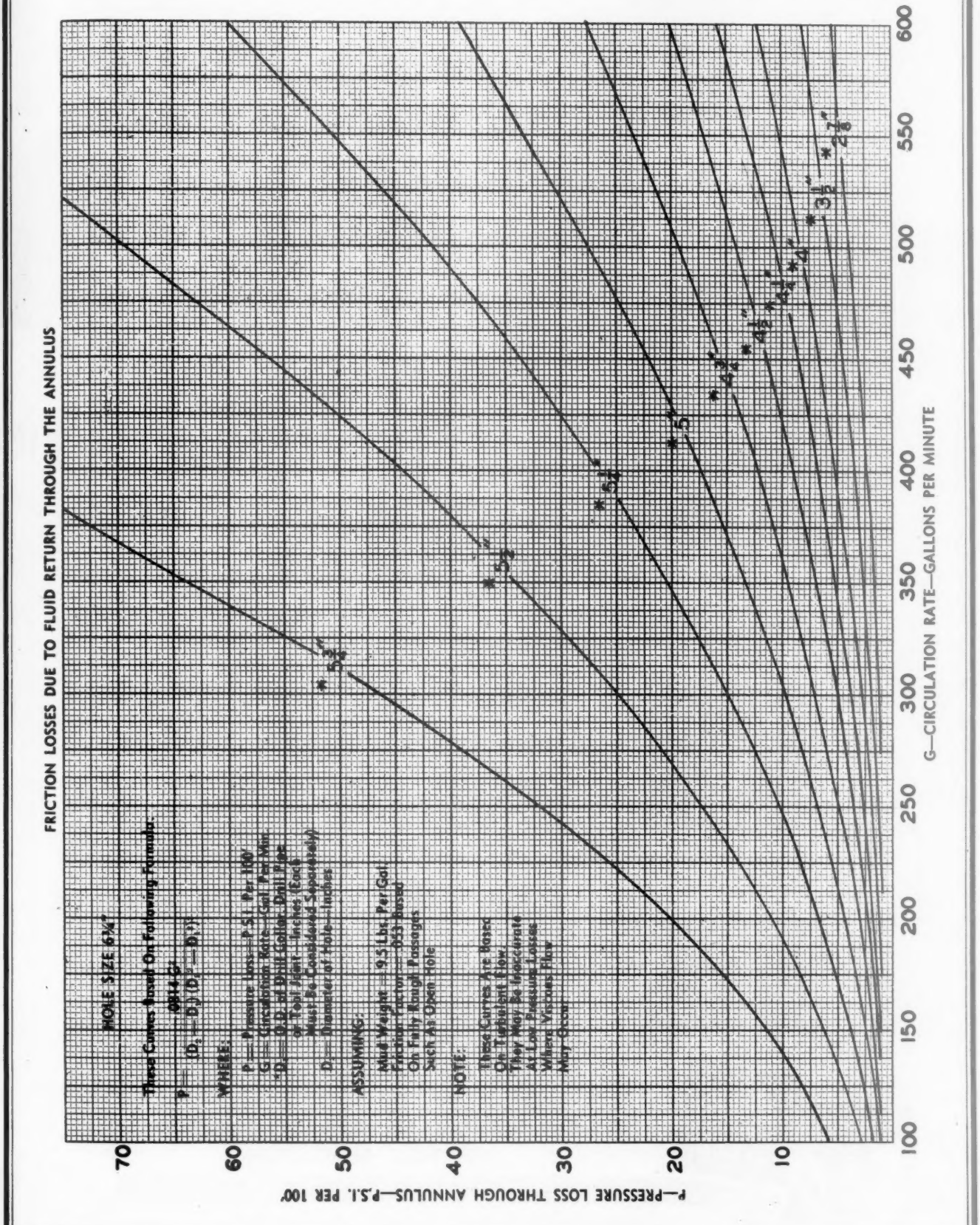
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

DRILLING HYDRAULICS



Courtesy of Hughes Tool Company

Note that cement lining is integral with the coupling on this end. Coupling is set up power tight and spot welded at the mill.
Sealing compound, supplied with each shipment, is applied here before pipe is inserted. Sealing material is easy to prepare and use. Resembles putty; sets up hard — provides complete protection.
Tees, ells, crosses, unions and other fittings supplied by the customer can be cement lined as a part of J&L service.

SALT WATER
SULPHUR WATER
ACID
CAUSTIC ALKALI
RUST
TUBERCULATION

....these things do not attack

J&L CEMENT LINED STEEL PIPE

J&L CEMENT LINED Casing, Tubing and Line Pipe combine the strength and economy of steel with a satin-smooth inner cement surface impervious to corrosive liquids.

This pipe is easy to install — no special skill required — and may be made up and broken down as often as necessary with no damage to the lining.

ASK FOR DETAILS—CALL YOUR J&L NUMBER OR WRITE US AT TULSA

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JONES & LAUGHLIN STEEL CORPORATION
SUPPLY DIVISION

Serving The United States and Canada
General Offices: TULSA, OKLAHOMA
J&L Tubular Products and Wire Rope

P·E·S·A
PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION
PARTNERS IN PETROLEUM PROGRESS

PROPERTIES OF CAST STAINLESS STEELS

Type	APPLICATIONS AND REMARKS
12CrLC	A mildly corrosion resistant alloy capable of being heat treated for high strength and hardness. Has a low coefficient of expansion. Used for valves and valve trim, pump parts, etc., especially in power plant and oil refinery equipment. Weldability is fair and machinability good after annealing.
12CrMc	Higher carbon content gives higher hardness after heat treating than CA15 with little sacrifice in corrosion resistance. Has same uses as CA15. Weldability is fair and machinability good after annealing.
12CrHC	Slightly less corrosion resistant than CA15. Capable of being heat treated to high hardness for abrasion and erosion resistance. Weldability is fair and machinability good after annealing.
12Cr-Tool Steel	A very highly abrasion resistant alloy for use under mildly corrosive conditions. Used in grinding rings for disposal units, abrasion plates, jet engine afterburners and all abrasive services not subject to great shock or severe corrosive conditions. Not weldable.
18Cr	Much better corrosion resistance than CA15. Cannot be hardened by heat treatment. Used for food processing, nitric acid and rayon manufacture, rabble blades in ore roasting furnaces, etc. Weldability is fair and machinability fairly good.
28Cr	Mainly a heat-resistant alloy, good in hot high sulfur bearing gases. Used for pump parts in erosive mine waters, nitric acid manufacture and in coarse high temperature parts. Brittle when slowly cooled to room temperature. Weldability poor to fair and machinability fair to good.
28-3	The small amount of nickel added to this alloy gives it much greater ductility than the CC50HC type; in general the uses are the same. Weldability is fair and machinability good.
28-3Mo	The addition of molybdenum to the 28-3 alloy provides for better corrosion resistance. Good in pump parts used for highly acid mine waters. Alloy is sometimes used to handle hot sulfite liquor in paper mills. Weldability is fair and machinability good.
28-3HC	A heat and corrosion resisting alloy with high abrasion and erosion properties. Used in As Cast conditions for roasting furnace blades, pump parts for handling abrasive and corrosive materials, protection plates, chemical mixing blades, etc. Weldability is poor and machinability is poor to fair.
18-8S	General purpose corrosion resistant alloy for applications in chemical, pharmaceutical, textile, and food processing industries, and in oil refineries. Carbon is held low for maximum corrosion resistance. Weldability and machinability are fairly good.
18-8SCb	Columbium is added to the CF8 analysis to prevent detrimental chromium carbide precipitation and intergranular corrosion, obviating heat treatment after welding operations. Same uses as CF8. Weldability and machinability are fairly good.
18-8SMo	The molybdenum addition to the CF8 analysis gives added corrosion resistance in sulfite liquors and many chemicals, reduces pitting corrosion, and helps prevent corrosion of the intergranular type. Weldability and machinability are fairly good.
18-8FM	Selenium addition to the CF analysis gives great ease of machinability and freedom from galling. Uses are the same as for CF20 except for heat applications. Weldability is poor to fair and machinability excellent.
18-8	Alloy for less exacting corrosion applications than CF8. Used largely for dairy processing parts and intermediate temperature heat applications. Weldability and machinability are fairly good.
20-10	Has slightly higher corrosion and temperature resistance than the CF20 type. Applications are similar. Weldability and machinability are fairly good.
8-20	An alloy resistant to medium temperatures and conditions of corrosion, used for electrical resistance grids, thermocouple wells, plugs in return headers in oil refineries, etc. Weldability is good and machinability fair.
18-8MoCuBe	A non-galling highly corrosion and erosion resistant alloy of high strength and hardness. Machinable in the quench-annealed condition before low temperature hardening. Used for valve discs, pump impellers, gears and other wearing parts. Only repair welding recommended.
20-25Mo	An alloy possessing better corrosion resistance to mild sulfuric acid concentrations than CF8M. Useful in the paper industry and in other similar applications. Weldability is good and machinability fair.
20-29MoCu	An alloy developed primarily for use in hot sulfuric acid of most concentrations. Has superior resistance to CF8M in all media. Weldability is fair to good and machinability good.
25-12S	An alloy having higher chromium and nickel contents than CF8 thus giving better corrosion resistance. Especially good in nitric acid, otherwise has same uses as CF8. Weldability is fairly good and machinability fair.
25-12SCb	Best chromium-nickel alloy for resistance to intergranular corrosion. Same uses as CF8C with better corrosion resistance. Weldability is fair and machinability fairly good.
25-12SMo	Has improved corrosion resistance over CF8M and similar uses. Weldability is fair and machinability fairly good.
25-12	An alloy for economical high temperature structural applications. Subject to embrittlement unless composition is properly balanced. Used for tube supports, dampers, and general furnace parts. Weldability is fairly good and machinability fair.
23-12W	A high strength and heat resistant alloy with a low creep rate. Used for heat applications where stress and hot gas corrosion rate are very high. Cast centrifugally in metal molds to form jet engine rings. Weldability and machinability fairly good.
29-9	For heat resistant use in fairly high sulfur bearing atmospheres and for corrosion resisting applications in hot sulfite liquor. Weldability and machinability are fair to good.
25-20	Best all around alloy for high temperature service except in presence of large amounts of sulphur gases. Higher nickel content makes it more stable than HH in similar applications. Weldability and machinability are fairly good.
15-35	Most widely used alloy for carburization and cyclic heating services. May be had with a columbium addition for added resistance to thermal fatigue cracking. Used for retorts, lead and cyaniding pots, heat treating trays and fixtures, etc. Weldability is fair and machinability good.
15-65	Premium alloy for carburizing and cyclic heating services in which it excells. Will not crack or warp. Must not be used in high sulfur bearing atmospheres. Used for retorts, lead and cyaniding posts, heat treating trays and fixtures, autoclaves, etc. Weldability and machinability are good.

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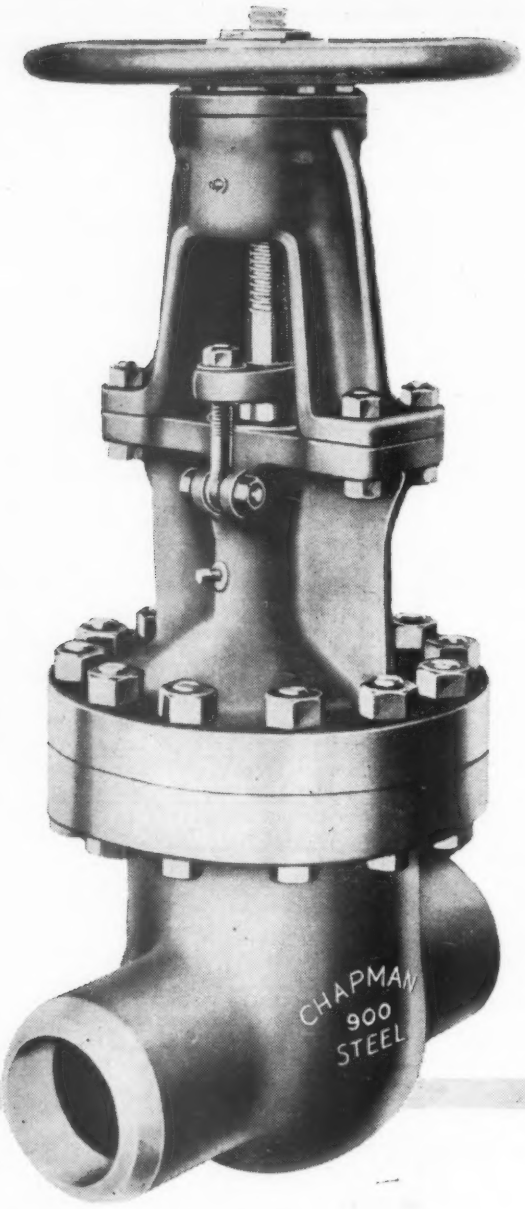
Two Reasons why
CHAPMAN
STEEL VALVES
Keep Maintenance Low in High Pressure Service



Carefully-formulated alloys and *accurately-detailed contours* give Chapman Steel Valves unexcelled dependability under the most severe high pressure and high temperature conditions.

Fourteen alloys are made in Chapman's own foundry, under rigid laboratory supervision, to ensure that every valve is made of the right steel for its specific service.

Precision manufacture to close tolerances is *standard* in Chapman Steel Valves. Designs have been refined to meet the demands of years of smooth operation at minimum maintenance costs. Quality is unsurpassed.

For gates, globes and checks in all pressure classes — 150, 300, 400, 600, 900 and 1500 psi — and for temperatures from —150°F to 1200°F, see Chapman first. Valves are supplied with bolted or welded body and bonnet joints and with flanged or welding ends. Valves equal or exceed API standards in every range.

Write for Catalog 20.

THE CHAPMAN VALVE MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

Estimating Data

3S-H14 and Alclad 3S-H14 Alloy Tubes

The weights below are nominal or theoretical weights based on 0.099 pounds per cubic inch.

Nominal Outside Diameter in Inches	SPECIFIED WALL THICKNESS Inch	Stubs' Gage No.	O. D. Surface Area in Square Feet per Linear Foot	Cross-Sectional Area of Bore in Square Feet	Weight in Pounds per Linear Foot
⅝	0.049	18	0.164	0.00151	0.105
	0.058	17	0.164	0.00141	0.122
	0.065	16	0.164	0.00134	0.137
	0.072	15	0.164	0.00126	0.148
	0.083	14	0.164	0.00115	0.168
¾	0.049	18	0.196	0.00232	0.128
	0.058	17	0.196	0.00219	0.149
	0.065	16	0.196	0.00210	0.166
	0.072	15	0.196	0.00200	0.182
	0.083	14	0.196	0.00186	0.206
	0.095	13	0.196	0.00171	0.232
	0.109	12	0.196	0.00154	0.261
⅞	0.049	18	0.229	0.00329	0.150
	0.058	17	0.229	0.00314	0.177
	0.065	16	0.229	0.00303	0.196
	0.072	15	0.229	0.00291	0.215
	0.083	14	0.229	0.00274	0.244
	0.095	13	0.229	0.00256	0.278
	0.109	12	0.229	0.00235	0.311
1	0.049	18	0.262	0.00444	0.174
	0.058	17	0.262	0.00426	0.204
	0.065	16	0.262	0.00413	0.226
	0.072	15	0.262	0.00400	0.248
	0.083	14	0.262	0.00379	0.284
	0.095	13	0.262	0.00358	0.320
	0.109	12	0.262	0.00334	0.362
	0.120	11	0.262	0.00315	0.393
	0.134	10	0.262	0.00292	0.432
1⅛	0.049	18	0.295	0.00575	0.196
	0.058	17	0.295	0.00555	0.230
	0.065	16	0.295	0.00540	0.257
	0.072	15	0.295	0.00525	0.283
	0.083	14	0.295	0.00502	0.322
	0.095	13	0.295	0.00477	0.365
	0.109	12	0.295	0.00449	0.412
	0.120	11	0.295	0.00427	0.449
	0.134	10	0.295	0.00401	0.495
1¼	0.049	18	0.327	0.00724	0.219
	0.058	17	0.327	0.00701	0.259
	0.065	16	0.327	0.00684	0.287
	0.072	15	0.327	0.00667	0.316
	0.083	14	0.327	0.00641	0.361
	0.095	13	0.327	0.00613	0.409
	0.109	12	0.327	0.00581	0.464
	0.120	11	0.327	0.00556	0.505
	0.134	10	0.327	0.00526	0.56
1⅜	0.049	18	0.360	0.00889	0.242
	0.058	17	0.360	0.00865	0.285
	0.065	16	0.360	0.00845	0.317
	0.072	15	0.360	0.00827	0.349
	0.083	14	0.360	0.00797	0.400
	0.095	13	0.360	0.00766	0.452
	0.109	12	0.360	0.00730	0.52
	0.120	11	0.360	0.00703	0.56
	0.134	10	0.360	0.00668	0.61
1½	0.049	18	0.393	0.0107	0.266
	0.058	17	0.393	0.0104	0.312
	0.065	16	0.393	0.0102	0.347
	0.072	15	0.393	0.0100	0.384
	0.083	14	0.393	0.00971	0.438
	0.095	13	0.393	0.00936	0.498
	0.109	12	0.393	0.00896	0.57
	0.120	11	0.393	0.00866	0.62
	0.134	10	0.393	0.00828	0.69
1¾	0.049	18	0.458	0.0149	0.311
	0.058	17	0.458	0.0146	0.367
	0.065	16	0.458	0.0143	0.408
	0.072	15	0.458	0.0141	0.46
	0.083	14	0.458	0.0137	0.52
	0.095	13	0.458	0.0133	0.59
	0.109	12	0.458	0.0128	0.67
	0.120	11	0.458	0.0124	0.73
	0.134	10	0.458	0.0120	0.81
2	0.049	18	0.524	0.0197	0.357
	0.058	17	0.524	0.0194	0.420
	0.065	16	0.524	0.0191	0.469
	0.072	15	0.524	0.0188	0.52
	0.083	14	0.524	0.0183	0.60
	0.095	13	0.524	0.0179	0.68
	0.109	12	0.524	0.0173	0.77
	0.120	11	0.524	0.0169	0.84
	0.134	10	0.524	0.0164	0.93

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CORRESPONDING DIFFERENTIALS—EQUAL FLOWS

FOR 10-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use, in.	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7
½	1.0	0.06	0.01											
1	16.0	1.0	0.20	0.06	0.03	0.01								
1½	81.0	5.1	1.0	0.32	0.13	0.06	0.03	0.02	0.01					
2		16.0	3.2	1.0	0.41	0.20	0.11	0.06	0.04	0.02				
2½		39.0	7.7	2.4	1.0	0.48	0.26	0.15	0.09	0.06	0.04	0.03		
3		81.0	16.0	5.1	2.1	1.0	0.54	0.32	0.20	0.13	0.08	0.05	0.04	
3½			30.0	9.4	3.8	1.8	1.0	0.59	0.36	0.23	0.15	0.10	0.07	0.04
4			51.0	16.0	6.6	3.2	1.7	1.0	0.62	0.40	0.26	0.17	0.11	0.08
4½			81.0	26.0	11.0	5.1	2.8	1.6	1.0	0.64	0.42	0.28	0.18	0.12
5				40.0	17.0	8.0	4.3	2.5	1.6	1.0	0.65	0.43	0.29	0.19
5½				61.0	25.0	12.0	6.6	3.9	2.4	1.5	1.0	0.66	0.44	0.30
6					38.0	18.0	10.0	5.9	3.6	2.3	1.5	1.0	0.67	0.45
6½					57.0	28.0	15.0	8.8	5.4	3.5	2.3	1.5	1.0	0.68
7						41.0	22.0	13.0	8.1	5.2	3.3	2.2	1.5	1.0

FOR 12-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use in.	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8
½	1.0	0.06	0.01													
1	16.0	1.0	0.20	0.06	0.03	0.01										
1½	81.0	5.1	1.0	0.32	0.13	0.06	0.03	0.02	0.01							
2		16.0	3.2	1.0	0.41	0.20	0.11	0.06	0.04	0.03						
2½		39.0	7.7	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03				
3		81.0	16.0	5.1	2.1	1.0	0.54	0.32	0.20	0.13	0.09	0.06	0.04	0.03		
3½			30.0	9.4	3.8	1.8	1.0	0.59	0.37	0.24	0.16	0.11	0.09	0.06	0.04	0.03
4			51.0	16.0	6.6	3.2	1.8	1.0	0.62	0.41	0.28	0.19	0.13	0.09	0.07	0.05
4½			81.0	26.0	10.0	5.1	2.7	1.6	1.0	0.66	0.44	0.31	0.21	0.15	0.11	0.08
5				39.0	16.0	7.7	4.2	2.4	1.5	1.0	0.68	0.47	0.33	0.23	0.16	0.12
5½				58.0	24.0	11.9	6.2	3.6	2.3	1.5	1.0	0.69	0.48	0.34	0.24	0.17
6				84.0	34.0	16.0	8.9	5.2	3.3	2.1	1.4	1.0	0.70	0.49	0.35	0.25
6½					49.0	24.0	13.0	7.5	4.7	3.1	2.1	1.4	1.0	0.71	0.50	0.36
7					69.0	33.0	18.0	11.0	6.6	4.3	2.9	2.0	1.4	1.0	0.71	0.51
7½						47.0	25.0	15.0	9.3	6.1	4.1	2.9	2.0	1.4	1.0	0.72
8						65.0	35.0	21.0	13.0	8.5	5.8	4.0	2.8	2.0	1.4	1.0

FOR 14-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use in.	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½
2	1.0	0.41	0.20	0.11	0.06	0.04	0.02									
2½	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03	0.02						
3	5.1	2.1	1.0	0.54	0.32	0.20	0.13	0.09	0.06	0.03	0.02					
3½	9.4	3.8	1.8	1.0	0.59	0.37	0.24	0.16	0.11	0.08	0.06	0.04	0.03	0.02		
4	16.0	6.6	3.2	1.8	1.0	0.62	0.41	0.28	0.20	0.14	0.10	0.07	0.05	0.04	0.03	
4½	26.0	10.0	5.1	2.7	1.6	1.0	0.66	0.45	0.31	0.21	0.16	0.12	0.09	0.06	0.05	0.04
5	39.0	16.0	7.7	4.2	2.4	1.5	1.0	0.68	0.47	0.34	0.25	0.18	0.13	0.10	0.07	0.05
5½	57.0	23.0	11.0	6.1	3.6	2.3	1.5	1.0	0.70	0.50	0.36	0.26	0.19	0.14	0.11	0.07
6	82.0	33.0	16.0	8.7	5.1	3.2	2.1	1.4	1.0	0.71	0.51	0.37	0.27	0.20	0.15	0.11
6½		47.0	23.0	12.0	7.2	4.5	2.9	2.0	1.4	1.0	0.72	0.53	0.39	0.28	0.21	0.16
7		65.0	31.0	17.0	9.9	6.2	4.1	2.8	1.9	1.4	1.0	0.73	0.53	0.39	0.29	0.22
7½		89.0	43.0	23.0	14.0	8.5	5.6	3.8	2.7	1.9	1.4	1.0	0.73	0.54	0.40	0.30
8			59.0	32.0	19.0	12.0	7.6	5.2	3.6	2.6	1.9	1.4	1.0	0.74	0.55	0.41
8½			79.0	43.0	25.00	16.0	10.0	7.0	4.9	3.5	2.5	1.8	1.4	1.0	0.74	0.55
9				58.0	34.0	21.0	14.0	9.5	6.6	4.7	3.4	2.5	1.8	1.3	1.0	0.75
9½				77.0	45.0	28.0	19.0	13.0	8.9	6.3	4.6	3.3	2.4	1.8	1.3	1.0

Example: The highest differential reading on a 12 in. by 6 in. orifice plate is 98 in. It is desired to install a 12 in. by 7 in. orifice plate to lower the differential. What will be the differential with the 12 in. by 7 in. orifice plate installed?

In the .2 in. flange section of the table find the 6 in. orifice size. In the column headed 7 in. at the intersection find .49. Multiply 49 by 98 in. and the new differential reading will be 48 in. on the 12 in. by 7 in. plate.

DARLING VALVES

The most important pipeline valve development in years

TRADE DARLING MARK McEvoy

New self-sealing two-way conduit valve for pipeline service automatically injects sealant by means of existing line pressure

Here's a new type of conduit gate valve, available in 8-inch and larger sizes, that gives positive downstream closure without dependence on metal-to-metal contact. Each time the valve closes, the required amount of sealant is applied automatically.

How it works

Employing the time-tested McEvoy principle, two cylinders, filled with special sealant, are located within the valve. Both are operated by line pressure. Depending on the direction of flow, line pressure actuates one or the other of these cylinders to force sealant into a channel in the downstream face of the seat. Since these cylinders hold enough sealant for 50 or more closures, the valves need only periodic servicing for recharging with sealant.

Write for details

Ask for bulletin #5402 which contains complete information on the design and operation of this valve.

DARLING VALVE & MANUFACTURING CO.
Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario

CORRESPONDING DIFFERENTIALS—EQUAL FLOWS

FOR 16-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use, in.	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½
1	0.06	0.03	0.01													
1½	0.32	0.13	0.06	0.03	0.02	0.01										
2	1.0	0.41	0.20	0.11	0.06	0.04	0.03	0.02	0.01							
2½	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03	0.02	0.02					
3	5.1	2.1	1.0	0.54	0.31	0.20	0.13	0.09	0.06	0.05	0.03	0.02				
3½	9.4	3.8	1.8	1.0	0.59	0.37	0.24	0.16	0.12	0.08	0.06	0.05	0.03	0.03		
4	16.0	6.6	3.2	1.8	1.0	0.62	0.41	0.23	0.20	.14	0.11	0.08	0.06	0.05	0.03	0.03
4½	26.0	11.0	5.1	2.7	1.6	1.0	0.66	0.45	0.32	0.21	0.17	0.13	0.10	0.07	0.06	0.04
5	39.0	16.0	7.7	4.2	2.4	1.5	1.0	0.68	0.48	0.35	0.26	0.19	0.15	0.11	0.08	0.07
5½	47.0	23.0	11.0	6.1	3.6	2.2	1.5	1.0	0.71	0.51	0.38	0.28	0.21	0.16	0.12	0.10
6	81.0	33.0	16.0	8.6	5.1	3.2	2.1	1.4	1.0	0.73	0.54	0.40	0.30	0.23	0.18	0.13
6½		46.0	22.0	12.0	7.0	4.4	2.9	2.0	1.4	1.0	0.74	0.55	0.42	0.32	0.24	0.19
7		62.0	30.0	16.0	9.4	5.9	3.9	2.6	1.9	1.3	1.0	0.74	0.57	0.43	0.33	0.25
7½		83.0	40.0	22.0	13.0	7.9	5.2	3.5	2.5	1.8	1.3	1.0	0.76	0.58	0.44	0.34
8			53.0	29.0	17.0	10.0	6.8	4.7	3.3	2.4	1.8	1.3	1.0	0.76	0.58	0.44
8½			70.0	38.0	22.0	14.0	9.0	6.2	4.4	3.2	2.3	1.7	1.3	1.0	0.76	0.59
9				49.0	29.0	18.0	12.0	8.1	5.7	4.1	3.1	2.3	1.7	1.3	1.0	0.77
9½				64.0	37.0	23.0	15.0	11.0	7.4	5.4	4.0	3.0	2.2	1.7	1.3	1.0

FOR 18-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use, in.	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½
2	1.0	0.41	0.20	0.11	0.06	0.04	0.03	0.02												
2½	2.4	1.0	0.48	0.26	0.15	0.10	0.06	0.04	0.03	0.02										
3	5.0	2.1	1.0	0.54	0.32	0.20	0.13	0.09	0.06	0.05	0.03	0.02								
3½	9.4	3.8	1.9	1.0	0.59	0.37	0.24	0.16	0.12	0.08	0.06	0.05	0.04	0.03	0.02					
4	16.0	6.5	3.2	1.7	1.0	0.62	0.41	0.28	0.20	0.14	0.11	0.08	0.06	0.05	0.04	0.03	0.02			
4½	26.0	10.0	5.1	2.7	1.6	1.0	0.65	0.45	0.32	0.23	0.17	0.13	0.10	0.08	0.06	0.05	0.04	0.03	0.03	
5	39.0	16.0	7.8	4.2	2.5	1.5	1.0	0.06	0.48	0.35	0.26	0.20	0.15	0.12	0.09	0.07	0.06	0.04	0.03	0.02
5½	57.0	23.0	11.0	6.1	3.6	2.2	1.5	1.0	0.70	0.51	0.38	0.29	0.22	0.17	0.13	0.10	0.08	0.06	0.05	0.04
6	81.0	33.0	16.0	8.6	5.1	3.2	2.1	1.4	1.0	0.73	0.54	0.41	0.31	0.24	0.19	0.15	0.11	0.09	0.07	0.05
6½		46.0	22.0	12.0	7.0	4.4	2.8	2.0	1.4	1.0	0.74	0.56	0.43	0.33	0.26	0.20	0.16	0.12	0.10	0.08
7		61.0	30.0	16.0	9.4	5.9	3.8	2.6	1.9	1.3	1.0	0.76	0.58	0.44	0.35	0.27	0.21	0.17	0.13	0.10
7½		81.0	39.0	21.0	12.0	7.7	5.1	3.5	2.5	1.8	1.3	1.0	0.76	0.59	0.46	0.36	0.28	0.22	0.17	0.14
8			53.0	28.0	16.0	10.0	6.6	4.5	3.2	2.3	1.7	1.3	1.0	0.77	0.60	0.47	0.37	0.29	0.23	0.18
8½			67.0	36.0	21.0	13.0	8.6	5.9	4.2	3.0	2.2	1.7	1.3	1.0	0.78	0.61	0.48	0.37	0.30	0.23
9			86.0	46.0	27.0	17.0	11.0	7.6	5.4	3.9	2.9	2.2	1.7	1.3	1.0	0.78	0.61	0.48	0.38	0.30
9½				59.0	35.0	22.0	14.0	9.7	6.9	5.0	3.7	2.8	2.1	1.7	1.3	1.0	0.78	0.62	0.49	0.39
10				76.0	44.0	28.0	18.0	12.0	8.8	6.4	4.7	3.6	.7	2.1	1.6	1.3	1.0	0.79	0.62	0.49
10½				96.0	56.0	35.0	23.0	16.0	11.0	8.1	6.0	4.5	3.5	2.7	2.1	1.6	1.3	1.0	0.79	0.63
11					71.0	44.0	29.0	20.0	14.0	10.0	7.6	5.7	4.4	3.4	2.6	2.0	1.6	1.3	1.0	0.79
11½					90.0	56.0	37.0	25.0	18.0	13.0	9.6	7.2	5.5	4.3	3.3	2.6	2.0	1.6	1.3	1.0

FOR 20-IN. FLANGES—Size of orifice plate to be installed, in.

Size of Orifice plate in use, in.	3	3½	4	4½	5	5½	6	6½	.	7½	8	8½	9	9½	10	10½	11	11½	12	12½
3	1.0	0.54	0.32	0.20	0.13	0.09	0.06	0.05	0.03	0.02										
3½	1.9	1.0	0.59	0.37	0.24	0.16	0.12	0.08	0.06	0.05	0.04	0.03	0.02							
4	3.2	1.7	1.0	0.62	0.41	0.28	0.20	0.14	0.11	0.08	0.06	0.05	0.04	0.03	0.02					
4½	5.1	2.7	1.6	1.0	0.66	0.45	0.32	0.23	0.17	0.13	0.10	0.08	0.06	0.05	0.04	0.03	0.02			
5	7.7	4.2	2.4	1.5	1.0	0.68	.48	0.35	0.26	0.20	0.15	0.12	0.09	0.07	0.06	0.05	0.04	0.03	0.02	
5½	11.0	6.1	3.6	2.2	1.5	1.0	0.71	0.51	0.38	0.29	0.22	0.17	0.14	0.11	0.09	0.07	0.06	0.05	0.04	0.03
6	16.0	8.6	5.1	3.2	2.1	1.4	1.0	0.73	0.54	0.41	0.32	0.25	0.19	0.15	0.12	0.10	0.08	0.06	0.05	0.04
6½	22.0	12.0	7.0	4.4	2.9	2.0	1.4	1.0	0.74	0.56	0.44	0.34	0.27	0.21	0.17	0.14	0.11	0.09	0.07	0.06
7	30.0	16.0	9.4	5.9	3.8	2.6	1.9	1.3	1.0	0.76	0.59	0.46	0.36	0.29	0.23	0.18	.15	0.12	0.10	0.08
7½	39.0	21.0	12.0	7.7	5.1	3.5	2.4	1.8	1.3	1.0	0.77	0.60	0.48	0.38	0.30	0.24	0.19	0.16	0.13	0.10
8	51.0	27.0	16.0	10.0	6.6	4.5	3.2	2.3	1.7	1.3	1.0	0.78	0.62	0.49	0.39	0.31	0.25	0.20	0.16	0.13
8½	65.0	35.0	20.0	13.0	8.4	5.7	4.0	2.9	2.2	1.7	1.3	1.0	0.79	0.62	0.50	0.40	0.32	0.26	0.21	0.17
9	82.0	44.0	26.0	16.0	11.0	7.3	5.1	3.7	2.8	2.1	1.6	1.3	1.0	0.79	0.63	0.51	0.41	0.33	0.27	0.22
9½		56.0	33.0	20.0	13.0	9.2	6.5	4.7	3.5	2.7	2.1	1.6	1.3	1.0	0.80	0.64	0.51	0.42	0.34	0.27
10		70.0	41.0	26.0	17.0	12.0	8.1	5.9	4.4	3.3	2.6	2.0	1.6	1.3	1.0	0.80	0.64	0.52	0.42	0.34
10½		88.0	51.0	32.0	21.0	14.0	10.0	7.4	5.5	4.2	3.2	2.5	2.0	1.6	1.3	1.0	0.80	0.65	0.53	0.43
11			64.0	40.0	26.0	18.0	13.0	9.2	6.8	5.2	4.0	3.1	2.5	1.9	1.6	1.2	1.0	0.81	0.65	0.53
11½			79.0	49.0	32.0	22.0	16.0	11.0	8.4	6.4	4.9	3.9	3.0	2.4	1.9	1.5	1.2	1.0	0.81	0.66
12			98.0	61.0	40.0	27.0	19.0	14.0	10.0	7.9	6.1	4.8	3.8	3.0	2.4	1.9	1.5	1.2	.0	0.81
12½				75.0	49.0	34.0	24.0	17.0	13.0	9.7	7.5	5.6	4.6	3.7	2.9	2.3	1.9	1.5	1.2	1.0

Example: The highest differential reading on a 16 in. by 6 in. orifice plate is 98 in. It is desired to install a 16 in. by 7 in. orifice plate to lower the differential. What will be the differential with the 16 in. by 7 in. orifice plate installed?

In the 16 in. flange section of the table find the 6 in. orifice size. In the column headed 7 in. at the intersection find 0.54. Multiply 0.54 by 98 in. and the new differential reading will be 52.9 in. on the 16 in. by 7 in. plate.

OIL and GAS TRADE NEWS

Gaso Appoints Distributor

Gaso Pump and Burner Mfg. Company has appointed Lufkin Foundry and Machine Company as distributor for Gaso Pumps in the Rocky Mountain area. Lufkin headquarters are at Casper, Wyoming, where Bob Miller serves as division manager and Roy Lilley, Jr., is in charge of sales and service.

Plasticool Appoints Agent

Earl Conley, president of Coating Laboratories of Tulsa, Oklahoma, has announced completion of arrangements with Archer-Sigler Corporation to act as national sales agents for Plasticool. "The Air Conditioned Paint." Plasticool, a sun-reflective paint, has recently received national publicity for its surprising performance in a variety of tests. Performance of the new paint is said to hinge on its ability to reflect the invisible or infar-red rays of the sun's spectrum as well as the visible rays.

O-C-T Names S. A. Agent

East West Oiltools, C. A. has been named South American representative for Oil Center Tool Company. Company will handle sale of O-C-T products in Venezuela, Colombia, Equador, Peru, South America, and Trinidad, B.W.I. East West Oiltools has widespread operations in South America representing such companies as Magcobar Drilling Mud, Franks Drilling Rigs, Universal Packing and Gasket Company. Cummins Gas Lift Valves, Red Devil Fluid End Parts, Burns Tool Company, and Bettis Rubber Company.

L. B. Harder is president of East West Oiltools. A. J. Thomas, C. L. Smith, and W. N. Thornhill are vice presidents.

New Company Formed

Formation of Walnesco Hydraulic Pipeline Testing Service, a new company to provide unitized pumping equipment for pipe line testing and other uses, has been announced. Company, with headquarters in Dallas. Texas, has Burt Hull, veteran pipeliner, as associate and consultant. Trained operating engineers are available if desired. Principal Walnesco equipment consists of Clark T-380-B Triplex piston-type pumps and Bryon-Jackson 6 by 8 by 10L two-stage centrifugal pumps, both mounted on heavy-duty skids and powered by General Motors Twin-6 diesel engines rated at 325 hp.

Oakite Opens New Lab

Oakite Products, Inc. has opened its new and expanded laboratories at 350 Hudson Street, New York City. The laboratory is subdivided into three major sections—product development, customer service, and engineering. A complete pilot plant is planned for the small scale manufacture of detergents and solvents prior to extensive field testing. Laboratory covers 30,000 sq ft on a single floor.

Worthington Presents Plaque

A bronze plaque was presented by Worthington Corporation to Bradford Supply Company recently at a dinner at Pennhills Club attended by executives of the two organizations. Presentation commemorated the long association of the two concerns dating back to 1926 and the part their combined efforts have played in providing water flooding equipment for secondary oil recovery.

John A. Carter, president of Oakite Products, Inc., pulls the switch to open the firm's new laboratory facilities.

Fittings Distributor Named

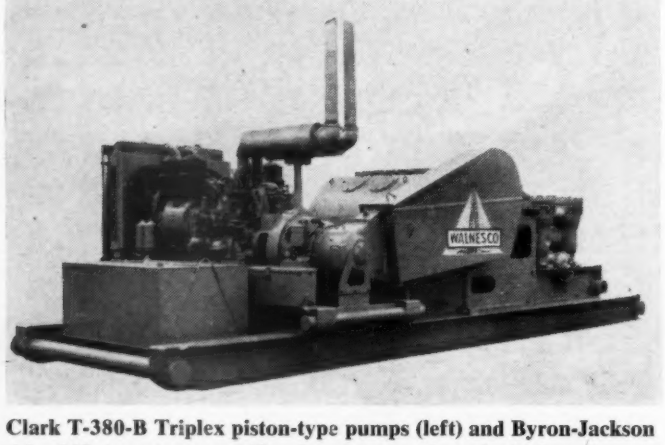
The Pacific Metal Company has been appointed a distributor of Tube-Turn aluminum welding fittings and flanges. Company is also a distributor for the Aluminum Company of America, and specializes in corrosion resistant metals and alloys.

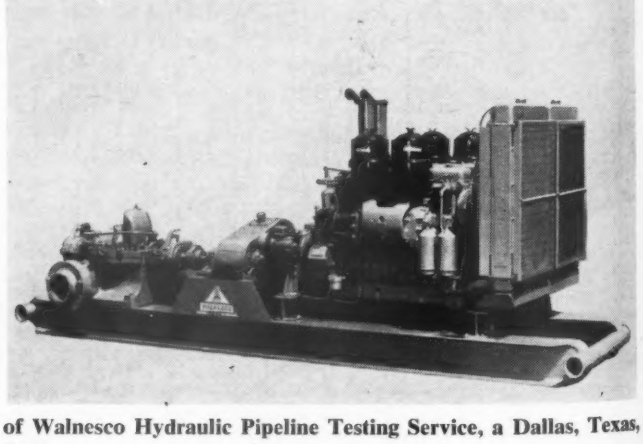
Ideco Distributor Named

Ideco, One of The Dresser Industries, has announced the appointment of Neyrpic--Afrique of Algiers, Algeria, as a distributor and repair depot for Ideco oilfield drilling, workover and servicing equipment, as well as other Ideco exclusive petroleum equipment and supplies. The new agent will serve the North Africa area including Algeria, Morocco, and Tunisia.

Company Undergoes Change

Rig Maintenance Supply Company of Houston, Texas, is now undergoing an extensive reorganization of its sales and service departments. Company will offer complete field and shop repair services for drillers in the Gulf Coast area with an adequate rig repair, supply, and service organization keyed to give speedy emergency and maintenance service. Shops and service trucks will be staffed with specialists in diesel and block repairs.





Clark T-380-B Triplex piston-type pumps (left) and Byron-Jackson 6 by 10L two-stage centrifugal pumps are the principal equipment of Walnesco Hydraulic Pipeline Testing Service, a Dallas, Texas, firm.

Participants in the 18th Prime Mover Control Conference held recently at Rockford, Illinois, included representatives from Greece, Peru, Mexico, Alaska, and Canada. The conference, sponsored by the Woodward Governor Company, included personnel from all types of major industries. Group studied controls for engines and turbines on both engineering and practical levels.

Fluor Purchases S&B

The Fluor Corporation, Ltd, has purchased a majority interest in Singmaster and Breyer, Inc. Firm has specialized in process engineering services for chemical and metallurgical industries.

Rockwell Tests Valves

Valves are literally being "beaten to death" in Rockwell Manufacturing Company's new meter and valve testing station. Valves are operated 24 hours a day at 25 per cent over their rated capacity, with each meter handling over 225,000 gal of gasoline every eight hours. Tests are standard practice at the testing station which was designed for the sole purpose of experimenting with and testing the various Rockwell meters and valves.

Dunham Appoints Agency

Dunham Tanks, a division of Anderson-Dunham, Inc., has appointed as its advertising agency, the Hayes, Wootters and Troxell firm, of Houston, Texas. Dunham Tanks' Minden plant has been completely over-hauled, modernized, and fully equipped.

Tool Rights Purchased

Fluid Packed Pump Company has announced the acquisition from the Knowlton Tool Company of the rights to manufacture sub-surface tools using the Knowlton vertical setting mechanism. By virtue of this purchase, Fluid Packed Pump Company will manufacture and market a complete line of packers, tubing anchors, liner hangers, and insert pump anchors.

Chemical Companies Win Award

Three chemical companies were among those receiving awards in the "Best Place to Work" competition sponsored by Management Methods. They are Stauffer Chemical Company, Columbian Carbon Company, and the Dow Chemical Company. Stauffer Chemical Company won first prize, as the "Best Integrated General Office."

Girdler Moves Headquarters

Headquarters of the Girdler Corporation of Canada Limited have been moved from 143 Yonge Street to Suite 911, 111 Richmond Street, West, Toronto. J. F. Babbitt is the Canadian representative of the company, which is a subsidiary of the National Cylinder Gas Company.

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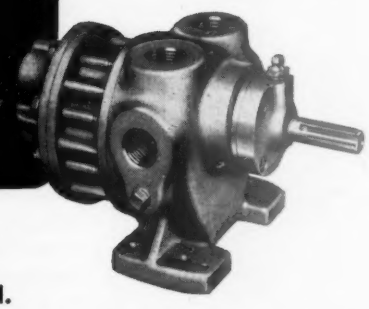

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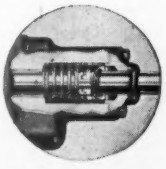

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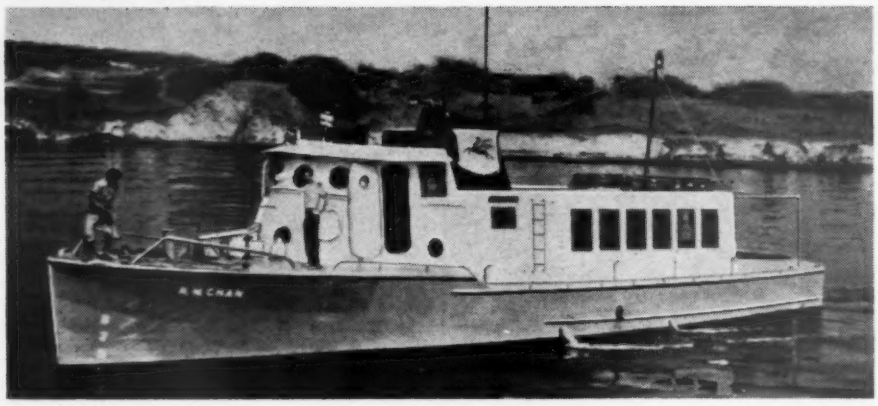
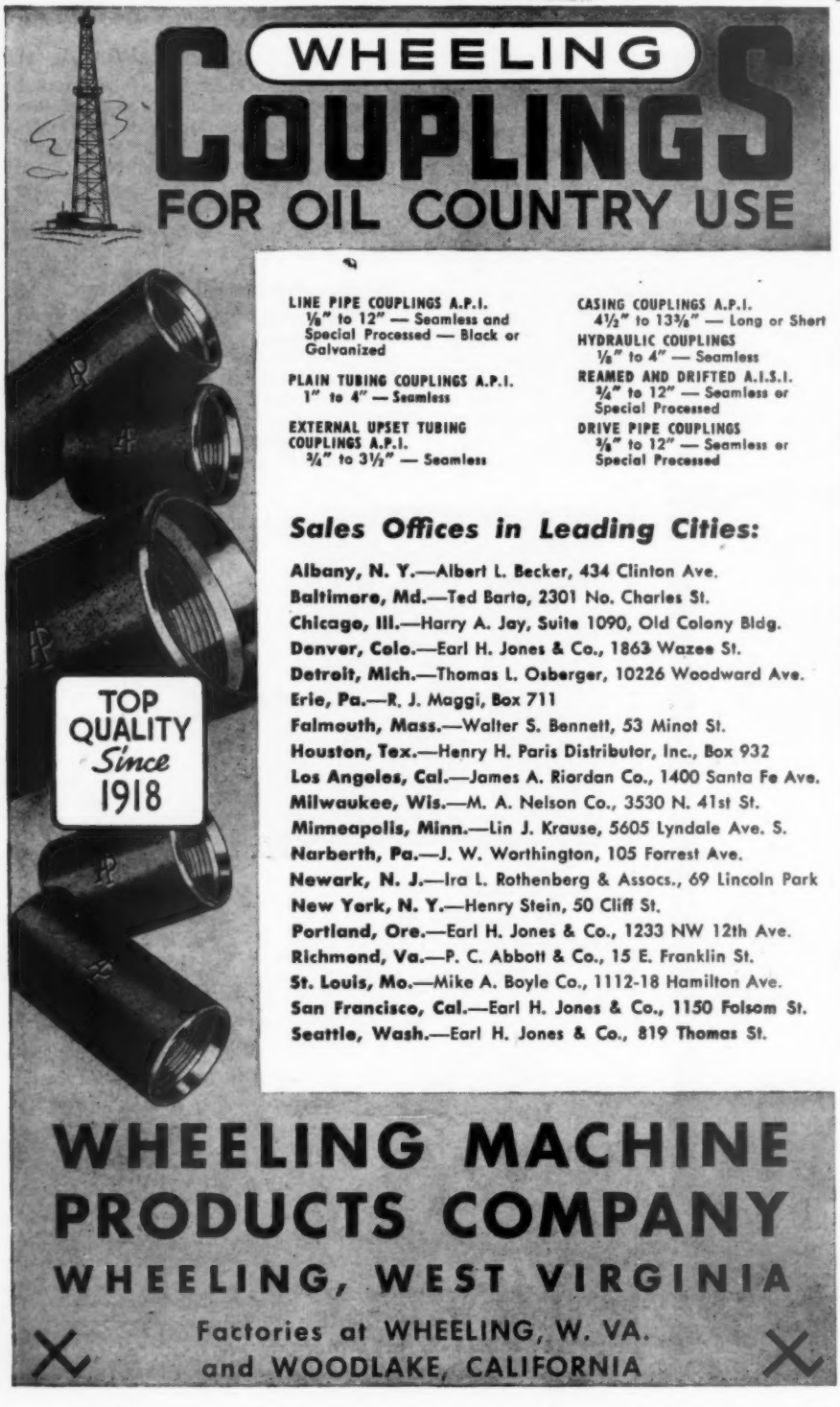


"R. M. Chan"—one of three crew boats built by Todd Shipyards Corporation for Magnolia Petroleum Company.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Newark, N. J.—Ira L. Rothenberg & Assocs., 69 Lincoln Park
New York, N. Y.—Henry Stein, 50 Cliff St.
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Mike A. Boyle Co., 1112-18 Hamilton Ave.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.
TOP QUALITY Since 1918
WHEELING MACHINE PRODUCTS COMPANY
WHEELING, WEST VIRGINIA
Factories at WHEELING, W. VA. and WOODLAKE, CALIFORNIA

Magnolia Buys Boats

Todd Shipyards Corporation has delivered 3 passenger crew boats, each 65 ft long, with a cruising speed of 14 miles per hour and passenger capacity of 24, to Magnolia Petroleum Company. Magnolia is using the boats to provide transportation for crews on its off-shore operations. Boats were designed and built to meet the requirements of the American Bureau of Shipping, and are equipped with accessories for lifesaving, navigation, etc.

Oil Base Names Distributors

Oil Base, Inc., has announced the following distributors for Black Magic and White Magic drilling fluids: Pacific Chemicals, Ltd., Calgary, Alberta, will represent Black Magic oil base drilling fluid and other Oil Base, Inc., products in Western Canada. Black Magic will also be represented in Canada by Clint Buffington, head of Autronics, Ltd. Carl Ingalls Trucking Company will be the exclusive distributor for White Magic emulsion mud throughout the San Joaquin Valley area. Mojave Corporation will represent White Magic exclusively in the Los Angeles basin and coastal areas of Southern California.

Dow Buys TV Program

"Medic," a television program, has been purchased by The Dow Chemical Company as its first full-sponsorship program on the national networks. Program will dramatize actual medical case histories, portraying real-life doctors and nurses engaged in the struggle for the preservation of life. It will be filmed in actual hospitals, clinics, and doctors' offices.

Mexico Receives Locomotives

Eight new 1600-hp diesel locomotives have been delivered to the Pacific Railroad (Ferrocarril del Pacifico) of Mexico by the American Locomotive Company, making a total of 25 Alco diesels operating on the road. Locomotives will be part of an over-all $80,000,000 four-year modernization program designed to rehabilitate the entire line, toward which the International Bank for Reconstruction made a loan of $61,000,000 on August 24.

Dow Offers Employees Stock

The Dow Chemical Company has announced a price of $33 per share on an issue of 200,000 shares of common stock to be offered to employees of the company, its subsidiaries and domestic associated companies under a payroll deduction plan. The new offering, to be known as the 1954 Employees' Stock Purchase Plan, will be the sixth since 1948 when the company first started selling common stock to its employees on an installment basis.

Lane-Wells Opens New Branch

Lane-Wells Company has opened a new branch in Pratt, Kansas. Quarters for the new office have been taken at 803 North Jackson. W. J. Gray is in charge of the new location. R. M. Johnson and Don E. Ruegsegger are members of the staff.

Chemical Process Opens Branch

The Chemical Process Company has opened a new branch at Hill City, Kansas. W. H. "Dub" Martin, formerly at Russell, Kansas, has been transferred to the new branch as district manager. E. C. "Chick" Efaw has been promoted to division manager in charge of operations at Russell, Great Bend, and Hill City.

Karl Peterson, product manager of Manning, Maxwell and Moore, Inc., demonstrates company's electronic process control system.

Instrument Exposition Held

The size and scope of the First International Instrument Congress and Exposition held in Philadelphia, Pennsylvania, in September was dramatically demonstrated by the number and diversity of one company's products exhibit, Manning, Maxwell and Moore, Inc. Exhibiting over 120 different products, many shown for the first time at the show, the 40 ft exhibit of the company built by Mastercraft Associates of New York, featured the company's electronic process control system. A new and improved line of safety relief valves were also featured.

Expansion Program Begun

The initial phase of an extensive expansion program, embracing production, sales, and sales promotion and advertising, has been accomplished at Enterprise Engine and Machinery Company, subsidiary of General Metals Corporation, San Francisco, California. Action involves broadening of product lines and development of new products, augmentation of the national sales staff, and a marked increase in the 1955 advertising program.

Rubber Companies Merge

The West Coast operations of Quaker Rubber Corporation and its recent acquisition, Pioneer Rubber Mills, Pittsburg, California, will be merged at once under the name Quaker Pioneer Rubber Mills, Division of H. K. Porter Company, Inc. Quaker Pioneer Rubber Mills will handle all the sales, manufacturing, and service operations of both companies in ten Western states. The pioneer and Quaker sales organizations will be combined in the East and operated under the Quaker Rubber Corporation.

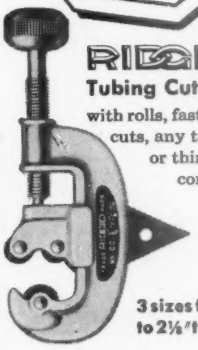
For Easiest Pipe Cutting ...it's a heavy-duty RIDGID

6 sizes: ⅛" to 6"— 4-wheel cutters to 4"

Every RIDGID Pipe Cutter TESTED for perfect tracking before shipment

Cut more pipe with less work with RIDGID

Once you've put a RIDGID Cutter on a pipe and seen how easily and cleanly it rolls through the metal, you won't want any other kind. Smartly balanced for easy action. Tracks perfectly—and special warp-proof malleable housing keeps it that way. High alloy thin-blade or heavy-duty cutter wheels, practically no burr. For fast cutting with least effort, ask your Supply House for a RIDGID.



RIDGID Tubing Cutter with rolls, fast easy cuts, any tubing or thin wall conduit.

3 sizes for ⅛" to 2⅛" tubing

THE RIDGE TOOL COMPANY, ELYRIA, OHIO, U.S.A.

RIDGID Work-Saver Pipe Tools

TRADE PERSONALS

Charles W. Haines has been named manager of petroleum industry sales development by Hewitt-Robins Incorporated. He will provide specialized sales assistance and guidance to members of the company's nation-wide field sales organization calling on the petroleum industry. Haines has been with Hewitt-Robins for three years. He was previously associated with the Shell Oil Company. Haines' office will be located in Stamford, Connecticut.

C. W. Haines

Walter L. Allen has joined Master Tank and Welding Company as their traveling sales representative in Texas and New Mexico. He has been a butane tank salesman since the end of World War II. Allen will have his headquarters in Luling, Texas.

W. J. Hickman, who has been field engineer at Tyler, Texas, for Schlumberger Well Surveying Corporation, has been transferred to Electra, Texas, as engineer-in-charge. **J. E. Stroop,** field engineer at Electra, has been transferred to Coleman, Texas, as location manager. He succeeds **H. B. Baskette,** who has gone to Gainesville, Texas, as location manager. **Calvin A. Smethie** has been sent to Haskell as location manager. He was formerly field engineer at Graham, Texas.

Don Mitchell, who was formerly location manager at Roswell, New Mexico, has been transferred to Dallas, Texas, as assistant to the division manager. **H. J. Nickel** has been transferred to Perry, Texas, as location manager. He was formmerly field engineer at Flora, Texas. **R. W. Bashe** has been transferred from location manager at Perry to Ardmore, Oklahoma, where he will take over location manager duties.

Everett P. Carley has been appointed to the position of chief engineer for the George E. Failing Company. **E. L. "Pete" Alexander,** former chief engineer, has been made a director of the company. Carley was graduated from Oklahoma A and M College with a B. S. degree in engineering. He has been with the Failing Company for 14 years, having formerly been associated with the Shell Oil Company and the Magnolia Petroleum Company.

Fred L. Goldsby, general sales manager for Chicago Bridge and Iron Company, has been elected a vice president of the company. **Raymond A. Johrde** was transferred to the company's Los Angeles sales office from the Tulsa sales office. **H. B. Funderburk** was transferred to the Houston sales office from the Birmingham, Alabama, plant. **George E. Borst,** who has been manager of the company's Philadelphia, Pennsylvania, sales office, was appointed manager of the New York sales office. **Lucian J. Harris,** formerly of the Los Angeles sales office, was appointed manager of the Philadelphia sales office.

Harry L. Simcox has been appointed a sales representative for Wolverine Tube, Division of Calumet and Hecla, Inc., in the east central district with headquarters in Columbus, Ohio. Simcox has been an office sales representative at Wolverine's general sales offices in Detroit, Michigan, since December 1953.

James T. "Red" Morris, veteran Houston advertising executive, has formed his own agency, Morris and Company, with offices at 3339 West Lamar, Houston, Texas. The new agency will specialize in industrial advertising. Morris plans to offer a field service to obtain good case history material and photographs, for oil industrial advertisers. He is a graduate of the University of Texas.

S. J. Stowell has been appointed sales manager for Tranter Manufacturing, Inc. He succeeds **J. R. Tepfer,** vice president who resigned July 31 as general sales manager.

Stowell has been merchandise manager of Tranter since 1953. He was formerly a district sales manager for Lonergan Manufacturing Company and Refrigeration Corporation of America.

Claude M. Smith, formerly with West Penn Electric Company, and also former utilities specialist for Price and Waterhouse, has joined the Fluor Corporation, Ltd., as manager of sales for utilities.

R. E. White

G. L. Gore

Richard E. White has been appointed as general manager and **Charles O. Bartley** as works manager of Mission Manufacturing Company. White has been employed by Mission since his graduation from Texas A and M in 1938. He began with the company as a junior engineer and worked up through the engineering and production ranks and was formerly works manager. Bartley joined the company in 1941. He was employed as a junior engineer and advanced through the ranks to the position of production superintendent. He is a graduate of Rice Institute.

George L. Gore has been promoted to petroleum engineer and transferred to Dowell Incorporated's Rocky Mountain operations area with district offices at Denver, Colorado. Gore joined Dowell in Great Bend, Kansas, in 1949 as a junior service engineer, shortly after his graduation from Oklahoma A and M College. He was transferred to Dowell's general offices in Tulsa as a development engineer in 1953.

Walter E. Sutter has been appointed manager of sales for instruments and industrial electronic products of the commercial equipment department of the General Electric Company. He will be responsible for the national sales of GE's electronic instruments such as laboratory power supplies, frequency meters, beta-gamma survey meters; and industrial electronic equipment such as industrial (closed circuit) television and factory automation. A graduate of Rensselaer Polytechnic Institute, Sutter joined General Electric in 1946.

V. A. Kelley

J. C. Clem

V. A. Kelley, formerly Mid-Continent sales representative and more recently representing Bethlehem Steel Company and Johnson-Fagg Engineering Company, has been appointed manager of production equipment supplies for Sargent Engineering Corporation. Kelley attended University of Oklahoma and worked as roustabout and roughneck for Hunt Tool Company and Sun Oil Company. He joined Sargent in 1936 at Shawnee, Oklahoma.

Stan Wright has been appointed application engineer for Sargent's gear division. Wright was educated in Scotland. He brings more than twenty years of specialized gear engineering experience to his new position.

James C. Clem has been appointed to the advertising and sales promotion staff of T. D. Williamson, Inc. **Don B. Crawford** has been made superintendent of production and purchasing agent.

Prior to joining Williamson, Clem was chief draftsman for Instruments, Inc. Before joining Instruments, Inc., he was with the Distributive Education Staff of Oklahoma A and M College at Stillwater, Oklahoma. Clem is a graduate of Oklahoma A and M. Crawford is a graduate of Oklahoma University. His engineering experience includes seven years with Stanolind Oil and Gas Company and four years as assistant chief estimator for the Refinery Engineering Company.

B. F. Whitbread has been named product sales manager for Gar Wood hydraulic hoists and dump bodies. Whitbread has been manager of Gar Wood's direct factory truck equipment sales branch in Los Angeles since 1950. He has been with Gar Wood almost 20 years, beginning as a shop laborer in 1935.

Ross Miller has been named sales manager of St. Paul Hydraulic Hoist. Miller was vice president and general manager of the National Lift Company prior to his appointment.

Richard P. George has resigned his position as regional superintendent for the International Petroleum Company, Ltd., in South America to become associated with M. "Bink" Manning, Inc., and M and R Specialty Company. A graduate of the University of Pittsburgh, George was employed by Phillips Petroleum Company and several drilling contractors prior to joining International Petroleum.

Stafford H. Wilde has been appointed division sales manager of Tellepsen Petro-Chem Constructors, a division of Tellepsen Construction Company of Houston, Texas. Wilde was associated with the Henry J. Kaiser Interests from 1930 to 1945. In 1945, Wilde organized the Bellco Industrial Engineering Company in Houston. Until his resignation on September 1, he served as vice president and director of the organization.

S. H. Wilde

B. O. Giddens has been promoted from city salesman in Odessa, Texas, to store manager of Mid-Continent Supply Company's Eunice, New Mexico, location. Giddens worked briefly with Mid-Continent in 1944-45 until he entered military service. He returned to the organization in 1949 at the Sundown, Texas, store.

W. F. "Pete" Slater has been named general sales manager of Kobe, Inc. Other promotions announced were: **R. G. Ralph,** named hydraulic service manager; **Ray Elner,** hydraulic sales manager, and **J. T. Lewis,** southern division sales manager.

M. E "Mike" Hause and **Carl A. Parker** have been appointed field coordinators for Republic Supply. Hause has been with Republic for two years and was formerly with the inventory control department. Parker recently joined Republic coming from Sinclair Refining Company, where he served as traveling auditor.

J. B. Sewell has been appointed general sales manager of The Garlock Packing Company. Beginning with Garlock in 1935 as salesman for the Montreal area, Sewell was appointed vice president of The Garlock Packing Company of Canada, Ltd., in 1947. He will take over the sales duties of Louis Mohn, a vice president of the company, who is on sick leave.

Robert L. Bell, formerly superintendent of metals, Carboloy department of General Electric Company, has been appointed manager of manufacturing engineering. Bell was formerly affiliated with Bates and Rogers Construction Company, and the Carboloy component of the Cleveland Wire Works. He is a graduate of Swarthmore College.

Robert A Canning, formerly manager of production engineering, has been named manager of quality control. Previous to joining Carboloy in 1946, Canning was affiliated with American Steel and Wire Company, A. F. Holden Company, and Acme Heat Treating Company. He is a graduate of M.I.T.

E. C. Graves, superintendent of fabricating, Carboloy Department of General Electric Company, has been named superintendent of product manufacturing. He was associated with Ford Motor Company and Ligon Brothers Tool and Die Company before joining the company in 1934.

Jack H. Gaston of Lynwood, California and **David L. Ankeny** of Huntington Park, California, have received four-year "work-study" scholarship awards to the University of Southern California. The educational plan is sponsored by the Axelson Manufacturing Company, division of the Pressed Steel Car Company.

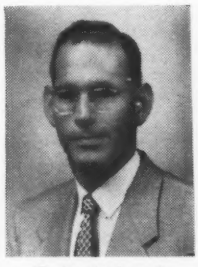
L. G. Smith, field engineer for Ensign Carburetor Company, has been transferred to the Pacific Northwest, to supervise sales and service activities. Smith began his career with Ensign in 1938 and has served in almost every division of the company including engineering, manufacturing, service, and sales. During the past seven years, he has been stationed at Lubbock, Texas.

Max Key, who has been in charge of Dow Chemical Company's Saran-Polyvinyl Chloride section, has been promoted to the newly established position of assistat plastic production department manager in charge of the department's Midland production operations. Key will have administrative responsibility for production in the Cellulose, Saran, Styron, and Vinyl Toulene sections.

A. T. Maasberg, who has been in charge of the department's cellulose products section, has been advanced to the newly created position of technical director of the department.

Madden T. Works has announced his resignation as chief engineer of Cameron Iron Works. He will do petroleum mechanical consultation work, specializing in drilling and production equipment design. Works was associated with Cameron for more than 22 years, joining the company's engineering department soon after his graduation from Rice Institute.

E. F. Brown


C. D. Richards

Edward F. Brown has been appointed sales engineer for Peerless Manufacturing Company and its subsidiary, Sillers Engineering Company. Brown will handle the expanded sales activities of both companies in the North Texas area, including Dallas, and Fort Worth.

Cooper D. Richards has been appointed assistant sales manager of Lufkin Foundry and Machine Company. Richards was formerly district manager at Oklahoma City, Oklahoma, for eight years. A graduate of the University of Texas, Richards was employed by Lufkin in 1936.

Replacing Richards in Oklahoma City is **Charles E. Dyer,** who has been resident manager of the Lufkin Machine Company, Ltd., in Edmonton, Alberta, Canada, since 1949. Dyer, who joined the company in 1933, was formerly district manager of the El Dorado, Arkansas, and Wichita Falls, Texas, offices. **Jack E. Gissler,** who has been employed by Lufkin since 1947, replaces Dyer. He has been North Texas district manager for the past 6 years.

J. B. Thompson has been transferred to Stockton, Kansas, to assume responsibilities of station superintendent of the Lane-Wells branch. Thompson has been with the Lane-Wells Company since 1947. He was formerly perforating and logging operator at Russell, Kansas.

Glenn Cooper, formerly in charge at Stockton, goes to Russell to take up duties as sub-district superintendent. He has been with the Lane-Wells Company since 1944.

ONLY 1½ MINUTES to weld joint in 12″ pipe fitting

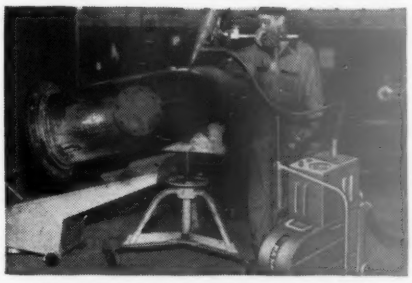


Figure 1. Perfect X-Ray Results *on welding flanges and fittings. Welding gun is mounted on inexpensive fixture.*

HIGH quality welds are now produced with single pass welds using Manual Lincolnweld. (Figure 1) Welding speeds average 25 inches per minute. No joint preparation is necessary, because high density currents used (up to 600 amp on 5/64″ electrodes) permit 100% butt welds on plates up to ¾″ with single pass from each side. The welds pass X-Ray inspection.

Through faster, easier welding, substantial cost savings are realized on construction and maintenance work where the work can be welded in the flat or near flat position. A lightweight welding gun and flexible cable permit free, easy movement for manual operation. (Figure 2) The welding gun can also be mounted on simple, inexpensive fixtures to provide the benefits of automatic welding at low cost.

Manual Lincolnweld is versatile for hardsurfacing of worn parts. Hardsurfacing is done with mild steel electrodes and Lincoln Agglomerated Fluxes in which the alloy is introduced through the flux.

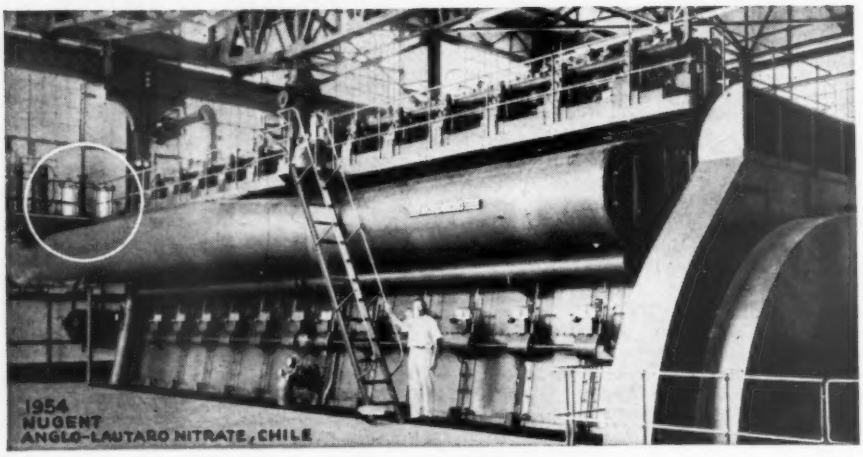
Figure 2. Free, easy movement *permits welder to guide welding gun for many types of down-hand operations for maintenance and fabrication work.*

HOW MANUAL LINCOLNWELD CUTS YOUR COST

Details in Bulletin 1303, available by writing.

THE LINCOLN ELECTRIC COMPANY
Dept. 2809, Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

MOST POWERFUL DIESELS



...rely on NUGENT FUEL OIL FILTERS!

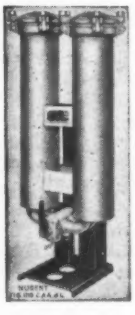
● The giant diesel shown above is one of two, 9,600 hp. Nordberg engines installed for the Anglo-Lautaro Nitrate Corporation at their plant in Coya Sur, Chile. The diesels are the most powerful single units ever built in the Western Hemisphere.

Included as original equipment on each of these engines is a Nugent #4L4 twin transfer filter (shown in circle above) for preliminary fuel oil filtering and a Nugent #4L Duplex fuel oil filter (not visible) to provide the final filtering. The Coya Sur installation is another example of Nugent filters being installed as original equipment by a leading diesel manufacturer.

Size for size, Nugent filters of the above type offer greater filtering area than any other filter on the market. In addition, the lubricating oil filters make possible a choice of full flow or by-pass with the same unit. Simple piping makes installation no problem.

No matter what the size of your own diesel power supply—no matter where it is installed, there is a Nugent fuel or lube oil filter to meet your needs. Write for complete information.

◀ Close-up of a Nugent #4L4 filter of the type used for fuel oil transfer on the giant diesels at Coya Sur. Recharges are inexpensive and simple to replace.



▶ Nugent duplex filter of the type used for final fuel oil filtering on the diesels at Coya Sur. By actual test, removes 99.8% of all foreign solids from fuel oil.

Wm. W. Nugent & Co., Inc.
416 N. Hermitage Ave. CHICAGO 22, ILLINOIS

OIL FILTERS, OILING AND FILTERING SYSTEMS, TELESCOPIC OILERS, OILING DEVICES, SIGHT FEED VALVES, FLOW INDICATORS
Representatives in Boston • Cincinnati • Detroit • Houston • La Junta, Colo. • Los Angeles • Minneapolis • New Orleans • New York • Philadelphia • Portland, Ore. • San Francisco • Seattle • St. Louis • Tulsa • Representatives in Canada: Montreal • Toronto • Vancouver

Trade Personals

▶ **Guy W. Bigham** has been appointed manager of the used equipment division of The Continental Supply Company. Bigham had been division sales representative for the Arkansas, North Louisiana, Mississippi, and East Texas division in Shreveport, Louisiana.

R. F. (Bob) Gregg has been named division manager of tubular sales for their Arkansas, North Louisiana, Mississippi, and East Texas division.

▶ **Robert S. Hinkle** has been appointed a member of Reilly Tar and Chemical Corporation's protective coating sales group. A graduate of the University of Illinois, Hinkle will have his headquarters in Granite City, Illinois. He will be associated with E. E. Goodman.

▶ **Charles C. Shackford** has been named product engineer of the electrical wire division of the John A. Roebling's Sons Corporation. Shackford joined Roebling in 1935 as a student engineer in the electric wire division.

▶ **Bruce E. Ellithorpe** has been named director of advertising and public relations for Axelson Manufacturing Company. He was formerly associated with Grant Advertising Agency as an account executive and with the Marlin Electric Company as sales manager. Ellithorpe received his education at Knox College and The Citadel.

Statement Required by the Act of August 24, 1912, as Amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) Showing the Ownership, Management, and Circulation of

THE PETROLEUM ENGINEER

Published Monthly, Semi-Monthly in July, at Dallas, Texas, for October 1, 1954.

1. The names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas, Texas.

Editor-in-Chief: F. H. Love, P. O. Box 1589, Dallas, Texas.

Managing Editor: Ernestine Adams, P. O. Box 1589, Dallas, Texas.

Business Manager: W. T. Bryan, P. O. Box 1589, Dallas, Texas.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)

American Security Life Insurance Company, Marshall, Texas.

Fidelity National Life Insurance Company, 403 South Akard, Dallas, Texas.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

Reserve Life Insurance Company, 403 South Akard, Dallas, Texas.

K. C. Sclater, 6365 Camino de la Costa, La Jolla, California.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

W. T. Bryan, Business Manager.

Sworn to and subscribed before me this 29th day of September, 1954.

[Seal] Lillian H. Johnston
Notary Public, Dallas County.
(My commission expires June 1, 1955.)

BOOKS ★

How to Operate Excavation Equipment, *Herbert L. Nichols, Jr., North Castle Books, Greenwich, Connecticut. Price, $1.50 paper bound, $2.50 hard cover. Pages, 150.*

Some of the material in this book won't be of much use to people in the oil industry, especially the part concerned with graders and rollers. The remainder, though, is extremely valuable as a reference book for methods that are new, and old ones that some may have forgotten. The author has done much to make the book easy to read, easy to understand, and filled it with useful illustrations. It should provide a training manual that construction people have been looking for and unable to locate. The author knows whereof he speaks, having been engaged in the construction business and operation of heavy equipment for over 20 years.

Gas Facts, *published by American Gas Association, Bureau of Statistics, 420 Lexington Avenue, New York 17, New York. Price, $2 for first 5 copies; $1.50 for each additional copy. Pages, 276.*

The scope of data relating to natural gas production and exploration, and to the composite financial experience of the gas utility has been increased in the eighth annual edition of "Gas Facts," the statistical yearbook of the American Gas Association. Statistics relating to the production of manufactured, mixed, and liquefied petroleum gas have been de-emphasized as these gases assume a position of lesser importance within the industry. These modifications were adopted after a survey of previous subscribers which sought ways of increasing the usefulness of the publication.

Volume presents all available information and pertinent quantitative data relating to reserves, production, transmission, distribution, and underground storage of gas. Customers, sales, revenues, financial results, construction expenditures, employees and prices are also covered.

Bibliography of Books and Published Reports on Gas Turbines, Jet Propulsion and Rocket Power Plants, *by Ernest F. Fiock and Carl Halpern, Supplement to National Bureau of Standards Circular 509, published by Government Printing Office, Washington 25, D. C. Price, 50 cents. Pages, 110.*

Rapid progress in the fields of gas turbine and jet propulsion has resulted in greatly increased literature covering the subject and also in a demand for coordination and exchange of relevant scientific knowledge. To cope with this demand and to enable the scientist or engineer to select with ease articles of specific interest, the National Bureau of Standards in 1951 issued *Bibliography of Books and published Reports on Gas Turbines, Jet Propulsion, and Rocket Power Plants,* by Ernest F. Fiock and Carl Helpern of the NBS Combustion Controls Section.

Original bibliography contains a brief introduction the classification and rating of jet engines and includes references on the status and future prospects, theory, and performance, materials and construction, and research programs in the gas-turbine and jet-propulsion fields. Some references are also given to papers on applications of nuclear power in this field.

Present supplement to circular 509 extends the period covered through December 1953. Approximately 5000 additional references are listed, including some reports of earlier date that have been declassified since the publication of the original bibliography.

POSITIVE OIL SHOW IDENTIFICATION with MINERALIGHT Ultra-Violet

(BLACK LIGHT)

Make sure you don't pass up possible pay! Make positive core identification checks with new model MINERALIGHT SL long wave ultra-violet lamp.

Proved best by test for oil show analysis!

No experience needed to operate. Lamp weighs only 1 lb. Models available for 110 volt AC or with adapter, 110 volt DC current. Battery operated model for field use holds lamp, has built-in viewer for daylight examination. Easily portable.

FREE

Send for illustrated brochure on how to detect and analyze petroleum in oil surface samples with ultra-violet.

ULTRA-VIOLET PRODUCTS, INC.

Dept. PE, 145 Pasadena Ave., South Pasadena, Calif.

HILCO LUBE and FUEL OIL PURIFICATION

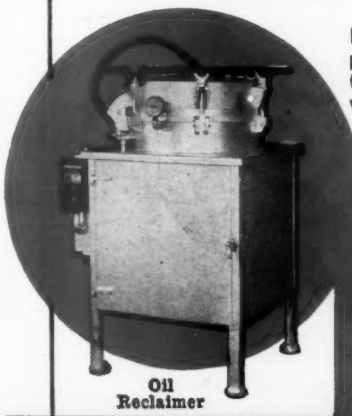
Get Rid of Dirty Oil . . .
Get Lower Operating Costs,
Longer Equipment Life

HILCO oil purification means complete oil purification! With a HILCO you get removal of sludge, acids, carbon, water and fuel dilution economically and efficiently. HILCO operation is continuous, all-electric and automatic.

Clean oil at all time reduces down time, increases production and HILCO units pay for themselves in savings.

HILCO offers a wide range of oil purification units . . . one to meet your needs. Write us about your equipment . . . and get recommendations at no obligation.

• *THERE'S A* ***HILCO*** *FOR EVERY LUBRICATION AND FUEL OIL FILTERING PROBLEM*



Oil Reclaimer

HILCO has 25 years experience in oil purification. Let this experience work for you.

- **PURIFIERS**
- **FILTERS**
- **RECLAIMERS**
- **CONDITIONERS**

A complete range of sizes and systems for oil purification.

• *WRITE FOR* ***FREE*** *LITERATURE ... NO OBLIGATION ON YOUR PART*

THE HILLIARD Corporation
209 WEST FOURTH STREET
ELMIRA, N. Y.

In Canada: **890 Yonge Street**
Upton-Bradeen-James, Ltd. • **3464 Park Ave., Montreal**

TAKE OUT THE SALT AND THE RISK...

with Visco

DESALTING TREATMENT

● Visco Desalting Treatments are your assurance of maximum salt removal and minimum risk of deposits, or plugged equipment. Used alone, or with electrical desalting, Visco formulas consistently and economically produce low salt content crude.

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Visco®... CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS

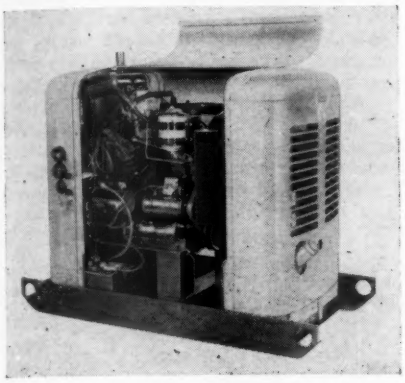
NEW oil and gas Equipment

- Machinery
- Supplies
- Services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(1) ENGINE POWER UNIT

The 4 Power Giant Industrial Engines produced by Willys Motors, Inc., are now being installed into a completely operat-



able engine package—The Willys Power Unit. It is fully equipped with a radiator, gas tank, air cleaner, complete electrical equipment, and governor. The enclosure is a heavy gage, steel housing designed for both rugged duty and appearance.

Circle number (1) on reply card.

(2) INTER-COM EQUIPMENT

Explosion-proof inter-communication equipment for hazardous industrial areas is now available from Executone, Inc. Equipment is equipped with explosive-proof or dust-tight Condulet switches, which enables inter-com stations to be installed in hazardous production areas where the presence of either flammable gases or vapors, or combustible dusts, prevents the use of ordinary inter-communication equipment.

Circle number (2) on reply card.

(3) CYLINDER ASSEMBLY

Improvements recently affected in the cylinder assembly of General Motors Series "71" Diesel engines is said to provide better fuel economy, increased horsepower in some sizes, and longer life for these power plants in all types of industrial, construction, and earthmoving equipment. Improvements are a new cylinder liner which provides a fresh flow of air into the cylinder, a new piston which increases the compression ratio, and longer-life compression rings. Liners and pistons are interchangeable.

Circle number (3) on reply card.

(4) GAGE

Elliott Company has designed a simple but accurate tube gage to measure the inside diameters of small tubes and tube sheet openings in condensers and heat exchangers. Designed primarily for use in conjunction with tube rolling operations, the Elliott gage can be read directly in thousandths of an inch and enables tube expanders and controls to be set accurately for exact tube-rolling.

Circle number (4) on reply card.

(5) CONTROL CENTERS

A new line of General Electric motor control centers has been developed by G. E.'s distribution assemblies department. To be known as DA7093, this center, according to General Electric engineers, will save up to 50 per cent in floor space. It will take 9 Nema size one starter units, or 6 Nema size two units in the standard 90-in. trough.

Circle number (5) on reply card.

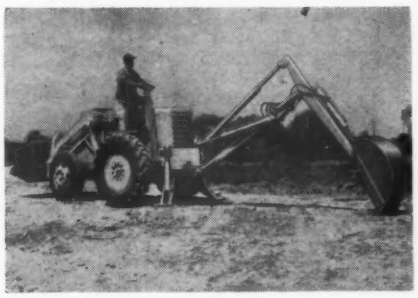
(6) PROCESS TIMER

A process timer, featuring "one knob" control has been announced by the General Electric Company's instrument department. Designated the TSA-21, the new product will control the timed simultaneous closing of one electric circuit and opening of another. The time scale of the timer is calibrated 0 to 100 per cent. Timer weighs 6¾ lb and measures 5¾-in. by 5¾-in. by 8 5/32-in.

Circle number (6) on reply card.

(7) BACK-HOE

An unusual type of back-hoe, designed specifically for the Hough PAYLOADER, has been announced by the Wain-Rov Corporation. Completely hydraulic, it is



designed to apply tremendous digging power, combined with fast retracting action, to speed up the entire operating cycle. Back-hoe provides an effective digging depth of 12½ ft below grade. It can dig trench and dump spoil at any radius up to 190 deg.

Circle number (7) on reply card.

(8) FIRE-FIGHTING UNIT

American-LaFrance-Foamite Corporation has developed a new fire extinguisher cart. The cart marks an advancement in mobile units. It permits one person to move three extinguishers easily.

Circle number (8) on reply card.

(9) TRUCK ENGINE

International Harvester Company has announced the International Royal Red Diamond 501 engine, standard in the International R-220 and cab-over-engine CO-220 series models and the 6-wheel model RF-230, is now optionally available in 12, 4, and 6-wheel chassis ranging upward from 30,000 lb GVW.

Circle number (9) on reply card.

(10) RADIO

The smallest commercial 10-watt two-way radio ever developed for mobile communications has been announced by the Engineering Products Division, Radio Corporation of America. The radio is 5½-in. high, 9¼-in. wide, 17¾-in. long, and weighs but 40 lb.

Circle number (10) on reply card.

(11) DIESEL ENGINE

New changes in the design of its D13000 diesel engine resulting in increased outputs have been announced by the Engine Division of Caterpillar Tractor Company. The D13000 marine engine shows increases of from 1000 to 1225 rpm and from 120 to 150 hp. The D13000 diesel electric set now operates at 1200 rpm and boasts an increase in capacity of from 80 to 100 KW.

Circle number (11) on reply card.

(12) MICROWAVE STATION

A commercial packaged microwave radio station—a compact, weather-proofed metal cabinet, housing complete transmitting and receiving equipment for "line of sight" one-hop point-to-point communication—has been announced by the engineering products division, Radio Corporation of America. The station package measures approximately 5 ft high, 2 ft wide, and 15 in. deep.

Circle number (12) on reply card.

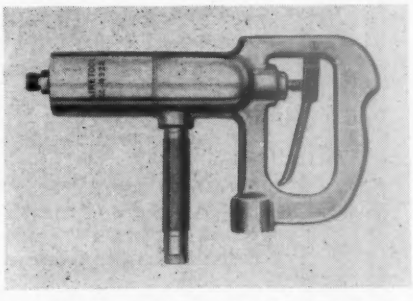
(13) TRANSFORMERS

Class H insulation made with Dow Corning silicones is now available on power transforming units. The heat resistance of the silicone insulation permits the transformers to be made smaller and lighter than similarly rated units. The high order of water repellency in the silicone gives excellent surface resistivity.

Circle number (13) on reply card.

(14) TUBE CLEANER

A new, lightweight condenser tube cleaner capable of cleaning completely plugged tubes up to 1-in. ID and smaller

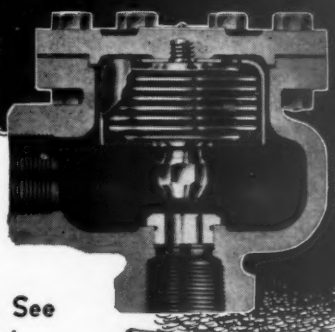


is now being made by The Airetool Manufacturing Company. Weighing only 11 lb, the cleaner operates at a high speed and cleans very fast. It is equipped with a muffler to reduce exhaust noise to a minimum and has a flushing system.

Circle number (14) on reply card.

NICHOLSON TRAPS

for every plant application



Send for Nicholson catalog 953. This 32-page standard reference on advance-type trapping of steam, air and other mediums contains: installation diagrams, charts for determining trap sizes, and advice on specific problems. See why leading plants are increasingly standardizing on Nicholson traps for increased production and minimum maintenance: thermostatic (illustrated) and metal expansion for pressures to 250 lbs.; weight and piston-operated, to 1500 lbs.

Send for Helpful Booklet

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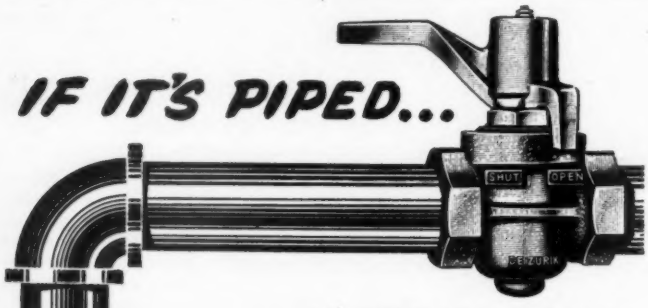

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Without Leakage!

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DeZURIK SHOWER COMPANY

SARTELL, MIINNESOTA

New Equipment

(15) CAT-LINE GRIP

A new roller type cat-line grip which combines all the safety features of the BJ standard models, but also provides a special sheave for added cat-line control, has been announced by Byron Jackson Company. This special sheave acts as a guide to give additional control in threading through the cat-line grip. Both roller type and standard models are designed to take 6000 lb working load with a 4-to-1 safety factor.

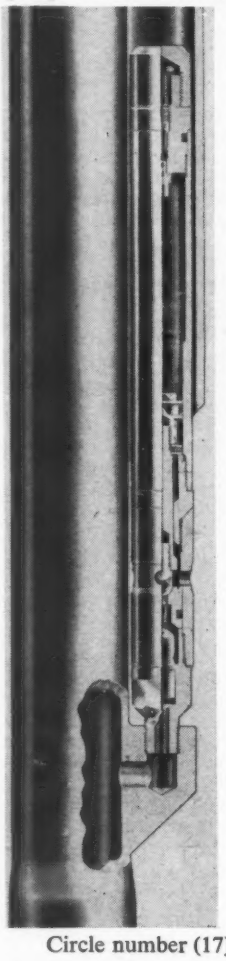
Circle number (15) on reply card.

(16) WATER BLOCK REMOVER

A new surface active material is now available to the petroleum producing industry for the removal of water blocks in oil bearing formations, according to Atlas Powder Company, manufacturers of the material, and Stanolind Oil and Gas Company who have developed and tested the method of application. Product, known as ATPET 931, is a unique, interfacial tension depressant. Non-ionic in nature, it gives excellent performance in the presence of varied oil field waters and brines, and will not "plate out" on solid surfaces.

Circle number (16) on reply card.

(17) GAS LIFT VALVE



Development of a new gas lift valve, the Merla Type "C" has has been announced by Merla Tool Corporation. Valve embody's a complete design change in single element gas lift valve construction, no bellows or springs are required. Basic design consists of an adaptation of an "O" ring on a piston. A carboloy main valve with nylon valve seat is an outstanding working feature which also includes a floating nylon back check. Built to withstand highest possible differential pressures, it is adaptable for intermitting and continuous flow operations and may be run in either, conventional or wire-line retrievable installations. Few working parts assure minimum maintenance costs.

Circle number (17) on reply card.

(18) INDUCTION MOTORS

New, re-rated, Tri-Clad "55" polyphase induction motors, available in quantity in ratings from one to five horsepower, has been announced by the General Electric Company's small integral motor department. NEMA frame sizes now available are 182, 184, 213, and 215. All ratings are available in totally-enclosed models as well as the regular drip-proof enclosure.

Circle number (18) on reply card.

(19) TANK GAGE

A revolutionary new tank gage which measures liquid depth by means of electronics has been announced by Gilbert and Barker Manufacturing Company. Gage uses no float or sonic mechanism and is actuated by electronic signals operating a Servo-motor. The motor, responding to the signals, raises and lowers a sensing element as liquid level rises or falls in the tank. Any petroleum product at temperatures up to 175 deg can be measured.

Circle number (19) on reply card.

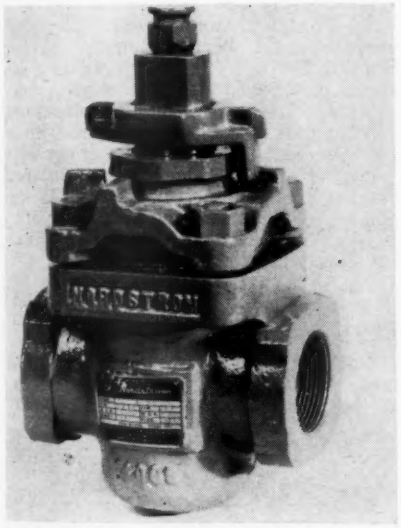
(20) CONDUIT VALVE

A new type of large diameter conduit valve has been manufactured by Darling Valve and Manufacturing Company. Positive seal is accomplished by means of a special sealant developed for this service. Two reservoirs within the valve contain enough sealant for about 50 operations of the valve. When the valve is closed, line pressure forces the sealant into a channel on the downstream face of the seat.

Circle number (20) on reply card.

(21) STEEL VALVES

A new line of lower-priced stanless steel Rockwell-Nordstrom lubricated plug



valves has been introduced by the meter and valve division of Rockwell Manufacturing Company. Featuring chrome-plated plugs, valves are suitable for most services in which the more expensive stainless steel valves have previously been used.

Circle number (21) on reply card.

(22) PLASTIC PIPE

A new lightweight flexible plastic pipe has been developed by Quaker Rubber Corporation, Division of H K. Porter Company, Inc. Pipe is made of 100 per cent virgin polyethylene resin, and guaranteed to be non-toxic. It is said not to rot, rust, or corrode, is easily handled, and requires no special tools to install.

Circle number (22) on reply card.

(23) RUST COATING

A new powerful weapon against rust damage is End-O-Rust, a new zinc rich, resin vehicle coating available from Industrial Craftsmen, Inc. Coating is said to bond to any iron or steel surface, even a rusty one, that is dry, free of grease and loose scale, and not painted with a tar or bituminous paint.

Circle number (23) on reply card.

(24) SHOES AND COLLARS

The Rector Well Equipment Company has recently announced new all-metal cementing shoes and collars. Designated as the Type "A," it uses a special aluminum alloy to replace the usual cement or bakelite internals in the conventional float shoes and float collars. The aluminum alloy has much greater impact, compression, tensile, and shear strength than either cement or bakelite.

Circle number (24) on reply card.

(25) WIRE LINE LUBRICATOR

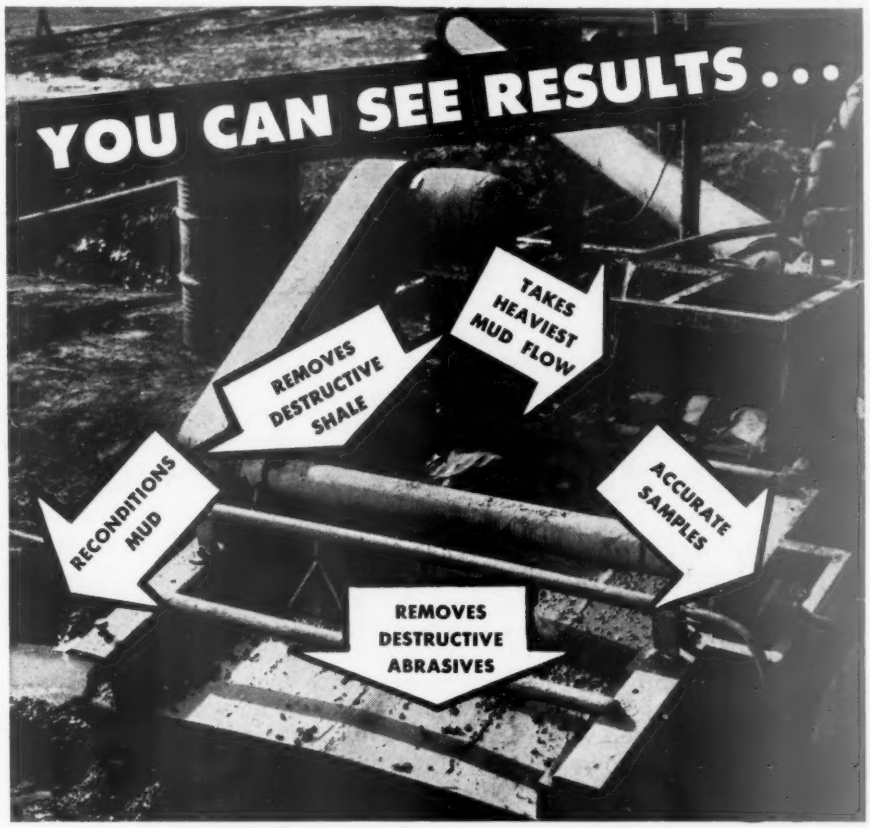
The Western Company Research Group has developed a wire line lubricator for use on high pressure wells. On one job 17 logs were run under 2000 lb of pressure without any leakage. On another job, well was kept under control during 15 perforating runs. Lubricator is applicable to permanent type well completion and will insure positive sealing on a moving stranded wire line.

Circle number (25) on reply card.

(26) SHUT-OFF VALVE

Ensign Carburetor Company is offering a vacuum controlled automatic shut-off valve for stationary and mobile LP-Gas engine installations. Valve consists of a vacuum controlled diaphragm shut-off valve actuated by manifold vacuum. When the engine is shut off or if the engine fails for any reason, the manifold vacuum ceases and the valve closes instantly. Only 2 to 6 in. of water column manifold vacuum are required to operate the valve.

Circle number (26) on reply card.



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VIBRATING SHALE SHAKER and SAMPLE MACHINE

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IOWA PARK, TEXAS

How a Sherman Power Digger Does More Work in Less Time with No Standby Equipment

Nearly every department in the city of Hopkins, Minnesota, finds a use for this versatile Sherman Power Digger.

The Water Department uses the machine when cutting off discontinued service lines at the main. They dig a hole in the street (usually blacktop) 3′ wide by 6′ long by 8′ deep. The hole must be plumbwalled for minimum replacement of paving. This operation used to tie up a truck all day, an air compressor half a day, and two men with hand tools, a full day.

Using a Sherman Power Digger, they now do *three* such jobs in one day, with only one man on the digger, no truck, and no compressor, except for concrete pavement. The job goes faster because they can dig the hole, shut off the line, and backfill before the walls begin to cave. Local soil conditions formerly required cribbing many of these excavations.

If *your* work involves the construction or maintenance of underground facilities, you will profit with a Sherman Power Digger. It's compact, fast, and flexible, with low initial cost and amazing economy of operation. Write today for full details, without obligation. Ask for Bulletin No. S16R

Designed, Engineered and Manufactured Jointly by
SHERMAN PRODUCTS, Inc.
Royal Oak, Michigan
WAIN-ROY CORPORATION
Hubbardston, Mass.

Patent No. 2,303,852
Other patents pending

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Sherman
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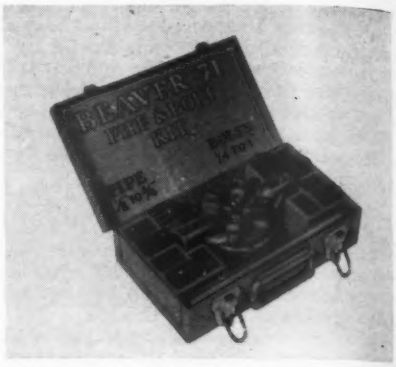
New Equipment

(27) PIPE AND BOLT KIT

Beaver Pipe Tools, Inc., is now marketing a compact pipe and bolt threading kit for use by plumbers, pipe fitters, electricians, and others. It provides storage space in the steel kit box for the threader and all basic dies, is lightweight and easy to carry or store. Kit includes the Beaver No. 71 hand threader; a set of ⅛ to ¾-in pipe dies; a set of ¼ to 1-in. bolt dies, and the Beaver No. 71-R ratchet.



Circle number (27) on reply card.

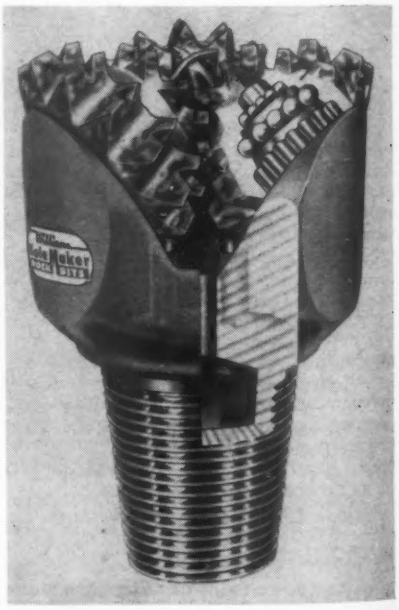
(28) WELDERS

A complete new industrial line of low maintenance, ac welders for high speed production has been announced by the General Electric Company's welding department. Welders feature stepless current control, silicone insulation, aluminum coil windings, and are equipped with a large current scale, which the operator can read from a considerable distance without returning to the welder. Designated 6WK30L, 6WK40L, and 6WK50L, the welders are available for 220/440 or 550 v operation.

Circle number (28) on reply card.

(29) DRILL BIT

Oil Tool Manufacturing Company has made a 3-cone rock bit for air or water Bit is made of nickel moly steel. It may be used for shale or hard rock formations, full or jet hole water courses. All bearing surfaces are ground finished and friction surfaces are undercut and Stellite metal added. Bit sizes are: 3¾, 3⅞, 4¼, 4½, 4¾, 4⅞, 5⅝, 6¼, 6¾, and 7⅞.



Circle number (29) on reply card.

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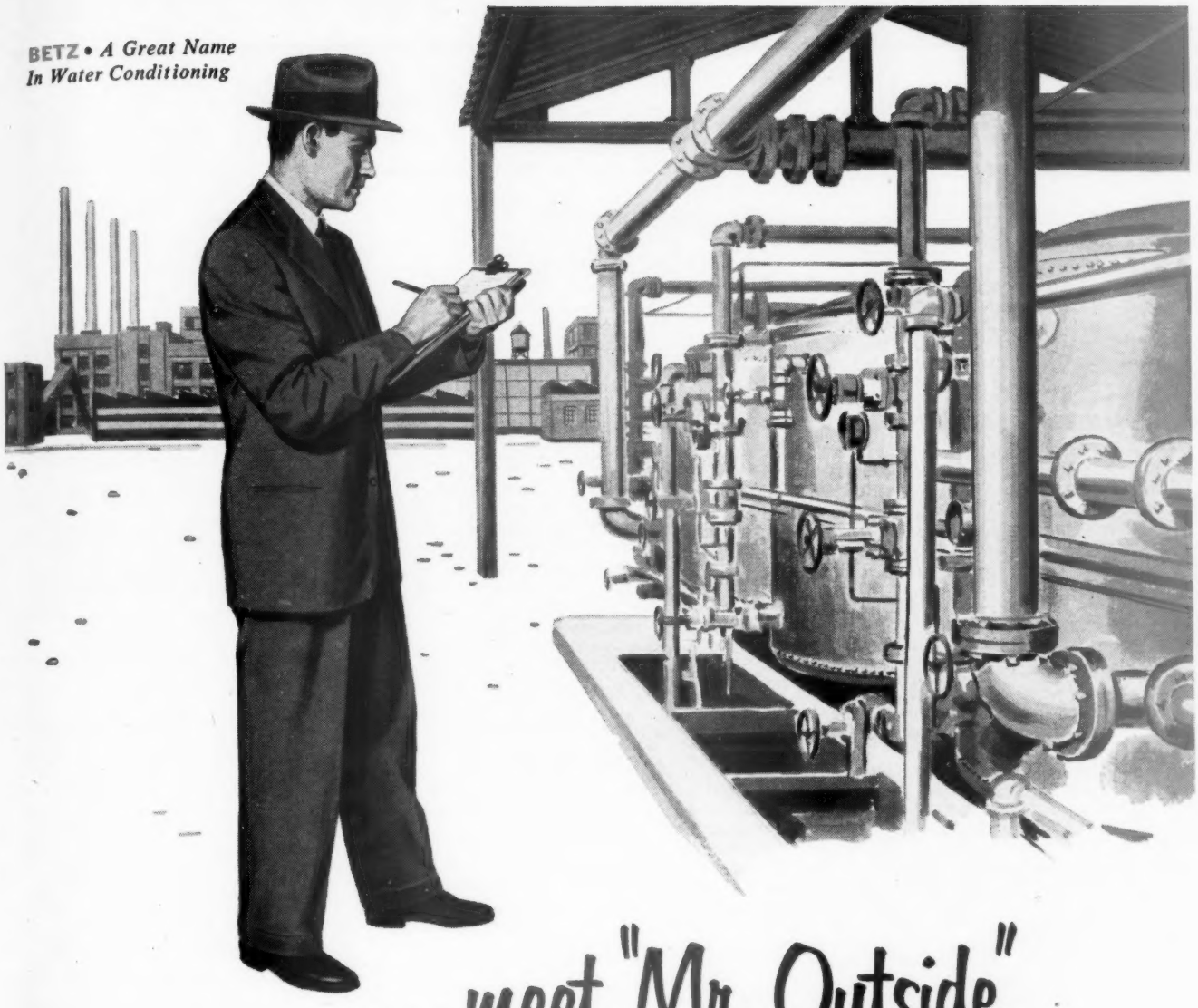

. . . meet "Mr. Outside"

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CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

NEW oil and gas Literature

- Brochures
- Bulletins
- Catalogs

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(30) CLEANERS

Kelite Products, Inc., has released a folder describing its various cleaning products for use in the petroleum industry. Folder is amply illustrated with drawings and photographs showing uses for various Kelite products. A list of products with a description of the operation is included.

Circle number (30) on reply card.

(31) WATER TREATMENT

Orchem Corporation has released a 48-page bulletin on its methods and products for the chemical treatment for water to be injected into oil reservoirs. A list of the various Orchem products and results of the use of the products are contained in the bulletin.

Circle number (31) on reply card.

(32) PRODUCTS CATALOG

A new edition of Bucyrus-Erie's general catalog (GC-5A), describing the company's complete line of excavating, drilling and material handling equipment, has been released. Designed for quick reading the 70-page, 2-color catalog features concise copy, condensed specifications and over 100 photo-illustrations of Bucyrus-Erie machines on specific jobs.

Circle number (32) on reply card.

(33) FLOW PICKUPS

A four-page folder has been released by Waugh Engineering Company describing its Model FL Flow Pickup. Pickups measure fluid flow by determining precisely fluid velocity in a passage containing a freely spinning turbine wheel. The turbine, which has four helical blades is mounted in the center of the straight through passage. A cantilever shaft, held in place by three radial vanes, supports the turbine. Diagrams of the pickup along with specifications, ranges and dimensions are included in the folder.

Circle number (33) on reply card.

(34) COOLING TOWERS

"Cooling Water for Industry," one of the most detailed explanations ever written of cooling tower construction and applications, is available on request from The Fluor Corporation, Ltd. The two color, 36-page, publication, designated as CT-ID-0.002, provides a description of Fluor induced-draft cooling tower construction. Bulletin is illustrated with photographs, sketches, cutaway and exploded drawings showing the detail of structural and mechanical equipment.

Circle number (34) on reply card.

(35) METERING VALVE

A four-page folder on its Csco Type CS-1900 fuel metering valve has been released by the Continental Supply Company. Folder contains a cut-away illustration of the valve and diagram showing the proper means of installing the valve.

Circle number (35) on reply card.

(36) UNIFLUX TRAY

Badger Manufacturing Company has issued a four-page illustrated bulletin (No. 10-M) describing the Uniflux Tray which it is licensed to manufacture and sell by the designer and owner of the patents, Socony-Vacuum Oil Company, Inc. The Uniflux Tray is a new type of removable section bubble tray of simple design, permitting high capacity at low cost.

Circle number (36) on reply card.

(37) AXIAL FLOW PUMPS

A four-page pamphlet has recently been published by Ingersoll-Rand on their class bpm mixed flow and apl axial flow pumps. Pamphlet incorporates dimensions, a materials table, and sectional drawings showing features of the pumps with detailed explanations of each. These units, specially designed for a wide range of process industry and paper mill applications, are now available in sizes 10 to 24 in. with pressures to 25 psi and capacities to 16,000 gpm.

Circle number (37) on reply card.

(38) TECHNICAL TERMS

A bulletin released by The International Nickel Company, Inc., explains over 150 technical terms that are used between suppliers and users of ferrous and nonferrous castings. Bulletin is offered to increase mutual understanding that promotes greater accord in working out the procurement of satisfactory castings.

Circle number (38) on reply card.

(39) RUBBER TESTS

Resistance to Abrasion, Flex Fatigue, and Tearing, is the title of E. I. du Pont de Nemours and Company's Neoprene Notebook No. 60, seventh in the "Language of Rubber" series telling how the rubber industry runs its tests and what the test results mean to engineers and designers of rubber parts. Notebook contains illustrations showing the various machines used in the different type test.

Circle number (39) on reply card.

(40) WAREHOUSE

H. B. Zachry Company has released a four-page folder outlining its methods of concrete factory and warehouse construction. A representative warehouse with specifications and price is illustrated in the folder.

Circle number (40) on reply card.

(41) PETROLEUM EQUIPMENT

Ideco, One of the Dresser Industries, has published a catalog on its petroleum equipment and supplies. Condensed Catalog No. 54 contains photographs and diagrams of Ideco equipment with a detailed explanation of the equipment illustrated. Performance charts and specifications of the different types of equipment are also included in the catalog.

Circle number (41) on reply card.

(42) GLYCOL

A new, four-page technical information bulletin on diethylene glycol and triethylene glycol has just been released by Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation. Both diethylene glycol and triethylene glycol are used to plasticize composition cork. They are also used in the dehydration of natural gas to prevent the formation of gas hydrates. Diethylene glycol is used in making thin glues and bindery adhesives more flexible. Triethylene glycol helps to control the bacterial content of air when vaporized in specially designed equipment.

Circle number (42) on reply card.

(43) OILFIELD EQUIPMENT

Black, Sivalls and Bryson, Inc., has announced the publication of three new, easy-to-use catalogs on oilfield equipment.

Catalog 31-11 describes the BS&B Low Pressure Vertical Free Water Knockout, Model LK. Highly suitable for processing wellstreams containing sand and sediment, the BS&L "LK" unit provides a deep settling section for efficient separation of free water . . . is available with either an adjustable water siphon or float type dumping mechanism.

Catalog 32-21 and 32-27 on the BS&B Series "70" Direct Heaters and Vertical Volume Heaters respectively, describe units that are used principally for heating wellstreams prior to entering flow tanks or for thermo-siphoning settled water in flow tanks.

All catalogs are well-illustrated with photographs, line drawings, charts, and graphs.

Circle number (43) on reply card.

(44) JELFLAKE

Dowell Inc. has published a four-page folder on Jelflake, Dowell's fragmented plastic foil. Jelflake is used to stop lost circulation problems encountered in both drilling and cementing operations. Dowell lists four advantages for the use of the foil: Easy to use; not affected by water, oil, mud chemicals, bacterial action, or high bottom-hole temperatures; will not ball-up; will not clog pump valves, and is light in weight.

Circle number (44) on reply card.

(45) EXPORT SERVICE

One-package export service is the subject of a new fully-illustrated four-page bulletin released by Ideco, "One of the Dresser Industries." Facilities are illustrated for planning complete drilling rigs, manufacturing components, grouping accessories, testing, packing for export and shipping from the port of Beaumont, Texas, located near the plant. Particularly stressed is the world-wide Ideco organzation which follows through field location for initial set-up and training of crews, as well as maintenance service.

Circle number (45) on reply card.

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at
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Want increased valve seat and disc life? Then specify FRANCE ASBESTOS BAKELITE VALVE DISCS — stronger and denser than ordinary Asbestos Bakelite Valve Discs; light . . . one fifth the weight of steel; high fatigue resistance . . . impervious to the corrosive action of many chemicals and moisture. Inquire, too, about FRANCE STEEL VALVE DISCS that are highly resistant to wear from impact.

MAXIMUM SERVICE for you in our NEW PLANT

Write for Complete Information

FRANCE PACKING COMPANY

9925 Bustleton Ave., Philadelphia 15, Pa.

(46) INFRARED ANALYZER

Data Sheet 10.16-7b, which describes the Process Controls (Division of Baird Associates, Inc.) Selective Infrared Plant Stream Analyzer, has been revised. The Analyzer, which uses a Brown ElectroniK potentiometer to record and, in some cases, control the concentration of one component gas or liquid in a plant stream, is said to be a valuable tool in production of petroleum products and chemicals.

Circle number (46) on reply card.

(47) VALVES

A new 20-page, two-color, illustrated pamphlet titled "Choosing the Right Valve" has been issued by Crane Company. Pamphlet contains a great variety of valve types, each with some special qualification for service. The important elements involved in choosing the right valve for the right job is also included in the pamphlet.

"It is a case of carefully matching the valve's service characteristics with the service requirements," the publication states. "It is a matter of knowing every detail of the job to be done—working pressure, temperature, fluid, volume of flow, corrosive elements, valve operating cycle, etc.

Circle number (47) on reply card.

(48) CARTRIDGE RESPIRATOR

A new chemical cartridge respirator with an "All-Vision" facepiece is described in a bulletin recently published by Mine Safety Appliances Company. The two-page bulletin shows the respirator in use and also lists different type cartridges for specific uses. The MSA "All-Vision" Chemical Cartridge Respirator was designed to allow better vision and more freedom of movement.

Circle number (48) on reply card.

(49) GAS TURBINES

A new publication explaining the application of gas turbines for gas pipe line pumping has been made available by the General Electric Company. The 12-page 2-color booklet, designated GEA-5962, contains detailed information on the operation and application of gas turbines for gas pipe lines.

Circle number (49) on reply card.

(50) CLUTCH

The Twin Disc Clutch Company, has announced the publication of bulletin No. 304 covering the Twin Disc Model PO Air-Actuated Clutch. The bulletin describes performance characteristics of the clutch for installations on all types of equipment in the oil fields, on cranes and shovels, on presses and brakes, hoists, and paper mill drives. Available are sizes 14 through 36 in. with torque capacities to 120,000 lb ft.

Circle number (50) on reply card.

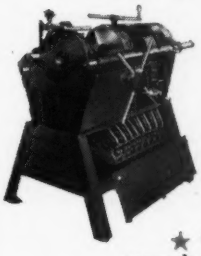
(51) GAGES

Catalog No. 246 covers in detail the three standard types of Jerguson Gage and Valve Company's Convex scale and flat scale truscale remote reading gages, showing how these gages bring the liquid level down to where it can easily be seen. Included are feaures of design and construction; description and schematics showing operation; schematics and charts graphically illustrating the three types of datum columns to meet specific needs, and illustrations and descriptions of gages.

Circle number (51) on reply card.

Step up
SPEED
THREADING ½" to 4" PIPE
Bring down Costs!

TOLEDO No. 1-2-4
POWER PIPE MACHINE
makes the job Easier!



★ *Threads 2" pipe in 18 seconds,* 3" in 30, 4" in 42.

★ *Cuts off 4" pipe in 9 seconds* with 4 high speed steel cutter knives, scroll fed.

★ *Instant size change . . .* separate quick-opening die head for each size pipe.

★ *High production . . .* performance proved! Order through your supply house.

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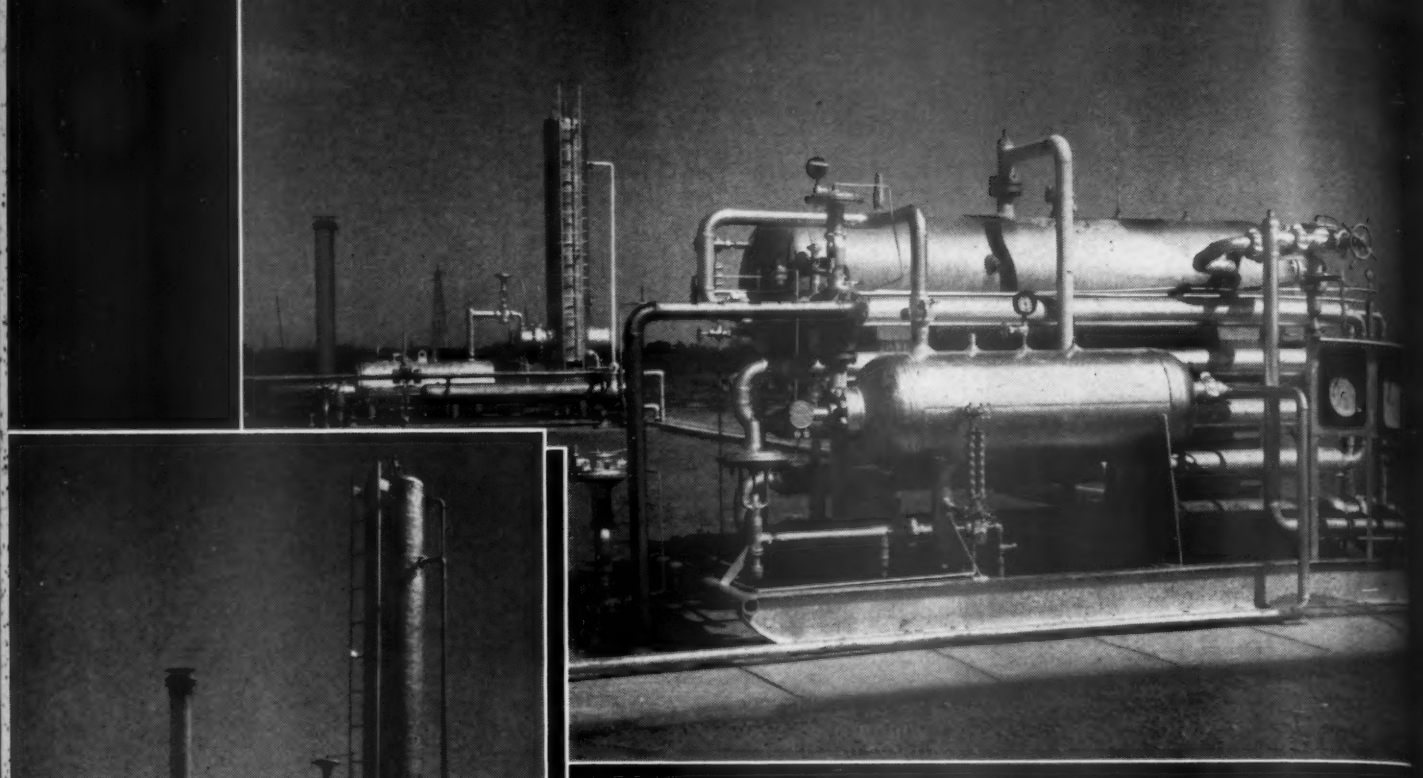
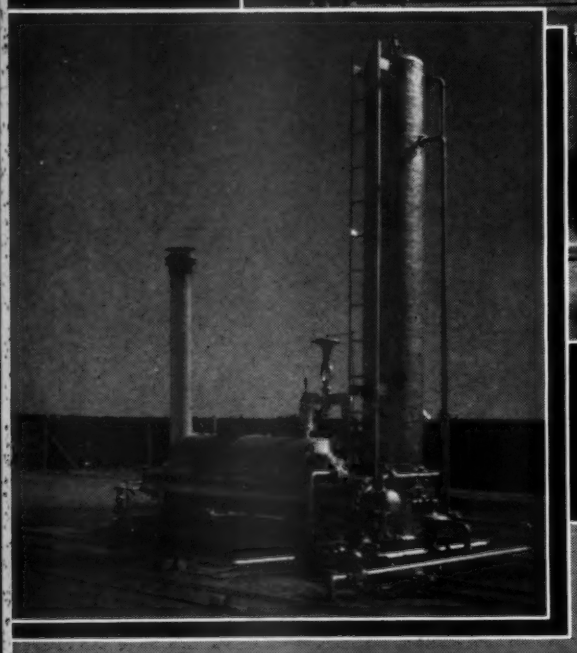
Toledo, Ohio





A 15 MMCFD, 1000# W.P. LTX UNIT and 500 BBL./DAY, 125# W.P. STABILIZING DESORBER

A NATIONAL "LTX® SYSTEM"

PER UNIT VOLUME OF WELL EFFLUENT PRODUCED

GIVES

❶ Maximum Stable Distillate Recovery

❷ Maximum High Pressure Gas Sales

❸ Maximum Trouble Free Performance

PLUS

The ability to operate with or without the injection of Glycol or other hydrate inhibitors.

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

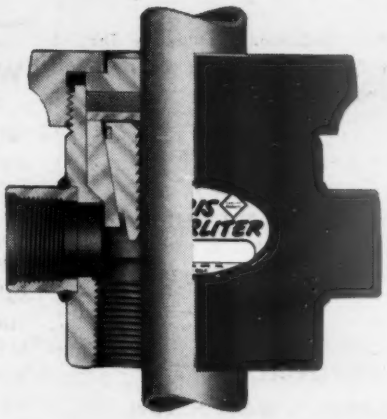
7-11-53

IT'S NEW AT NORRIS!

TO REDUCE YOUR LOW-PRESSURE WELL COMPLETION COSTS

THE TYPE WCN TUBING HEAD

1,000 Lb. C.W.P.



The WCN Tubing Head is basically a Hinderliter design — with all the adaptable features of the higher rated heads — at a price to cut your completion costs on wells within its recommended pressure rating.

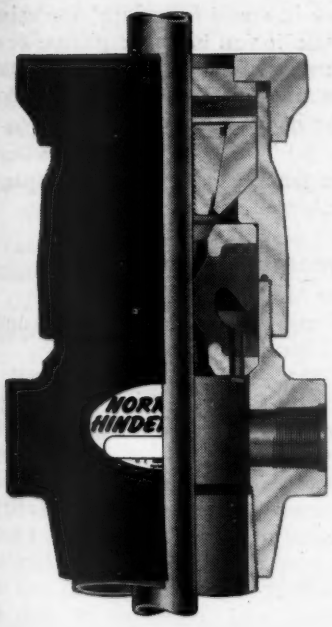
NORRIS HINDERLITER — QUALITY PRODUCTS — Top Quality WELL HEAD EQUIPMENT — W. C. NORRIS MFR. INC. TULSA, OKLA.

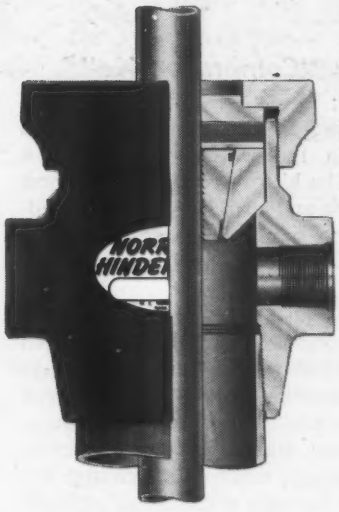
DEPENDABLE CONSTRUCTION — FULL OPENING — it is adaptable to acidizing, repressuring, water flooding — various completion and production methods.

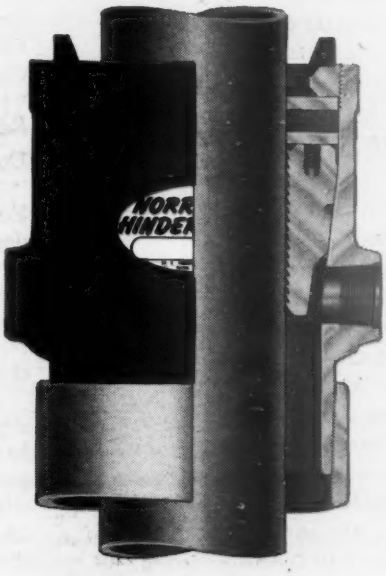
The CAP FEATURE of the WCN assures positive holddown of the packing element when tubing is suspended, and provides a tubing spider base for running and workover jobs.

For ECONOMY—FLEXIBILITY—SAFETY—SPECIFY WCN.

All Tubing and Casing Heads in the Norris Hinderliter line combine functional design with expert machining, accurate gaging, and thorough testing to insure safe performance.







HW Four-in-ONE AND HW Two-in-One TUBING HEADS
4,000# Test Pressure — 2,000# Cold Working Pressure

YLS Casing Head
2,000# Test

Write for Well Head Equipment Bulletin for complete information.

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TULSA, OKLAHOMA

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LETTERS ★

Wants Pamphlets Also

We are very much interested in the series of articles known as "Fundamentals of Rotary Drilling" which you intend publishing and to be included with the regular monthly issues of *Petroleum Engineer*.

While we have just renewed our subscriptions for five copies monthly and will be assured of getting these articles periodically, we would like to have them in pamphlet form, so that we may place them in folders and send them to our superintendents.

J. E. Burden
Pioneer Drilling Company, Inc.

Copies Wanted In Field

I found very informative and useful the article, "Formation Testing," by C. V. Kirkpatrick in your October 1954 edition of *The Petroleum Engineer*.

I should like very much to obtain additional copies of this article for our boys testing in the field. I should appreciate very much if you could supply us or inform us how we may acquire these copies.

K. Murray MacKenzie
Drill Stem Testers Limited
Edmonton, Alberta
Canada

Review "Comprehensive"

Dear Sir:

"Taming Wild Gasoline" by Arch Foster in the October issue was a dandy. The history reviewed was most interesting and correlated the outstanding events so comprehensively that even the old timers will have a better picture of the amazing evolution of the industry.

The progress of "light ends" from orphan to almost "favored son" stage has taken a long time. The improved processes and new uses for products which you mentioned were factors which brought much of the change but they also brought a change of attitude on the part of some oil leaders whose sole yardstick of progress had been barrels of crude. Many of these are now large producers of natural gas liquids and have found they really can be used to good advantage. I hope some of them also read your story and have a qualm or two on what might have been their position with an earlier realization of light ends value.

William F. Lowe
Natural Gasoline Association
of America
Tulsa, Oklahoma

Refinery Symposium

Thank you very much for copies of The Petroleum Engineer which carried an article on Refining Maintenance Symposium. (Refining and Petrochemical Edition, July Issue, 1954) These have been placed in the hands of our field service men.

F. B. Applegate
Pacific Pumps, Inc.

Thank you very much for sending us the copy of Refining Maintenance Symposium. . . . certainly am looking forward to reading it. The copy, of course, will be sent to the fluid cooler product sales manager. If we will need additional copies, I'll let you know.

David Cordry
Advertising Department
The Trane Company

Wants Skelly Well Picture

We are very interested in securing a copy of a color print published by you some time back of the Skelly Well on fire in Ector County (*The Petroleum Engineer* October issue). If you would kindly send a copy of this print to this office it would be greatly appreciated.

Also if you have the picture or any information on it, would you please inform us of the print of the Boom Days in Burkburnett.

Carole Stewart
Dunigan Tool and Supply Company
Breckenridge, Texas

Remembers Founding

Dear Sir:

Congratulations on a simply wonderful 25th Anniversary issue.

I read with particular interest the piece by Frank H. Love beginning on page A-73 and reproducing a cover of the October, 1929 issue. I remember so well the time when Tom Crowley, Clarence Morris, and W. T. Bryan founded this great publication. I know as a good friend of *Petroleum Engineer* something of your early trials and tribulations, and something of your important and triumphant series of successes which is definitely crowned by this particular issue.

Another intriguing article to me is the one by Ernestine Adams, "Battle of Energies." This is a piece which I believe every one in the oil industry should read and read again.

Please give my best wishes to every member of the great team which produced your 25th Anniversary issue.

Albert Evans, Jr.
Evans and Associates
Fort Worth, Texas